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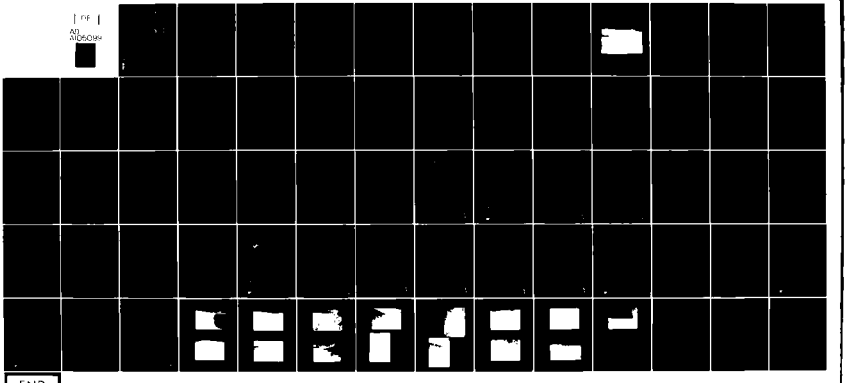

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MISSISSIPPI-KASKASKIA-ST. LOUIS RIVER BASIN

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LAKE BOUTIN DAM
CAPE GIRARDEAU COUNTY, MISSOURI
MO 40008

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

FEBRUARY 1981

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Lake Boutin Dam (MO 40008)

This report presents the results of field inspection and evaluation of the Lake Boutin Dam. It was prepared under the National Program of Inspection of Non-Federal Dams.

The inspection results indicate that this dam is in generally poor condition due to the steep embankment slopes of questionable stability and other deficient items detailed within the report.

The owner should take immediate action to have stability and seepage analyses performed for this dam by an engineer experienced in earth dam design. Additionally, the remedial measures concerning the downstream slope and spillway channel should be undertaken on a high priority basis.

SUBMITTED BY: SIGNED 16 APR 1981
Chief, Engineering Division — Date

APPROVED BY: SIGNED 20 APR 1981
Colonel, CE, District Engineer — Date

MISSISSIPPI-KASKASKIA-ST. LOUIS RIVER BASIN

LAKE BOUTIN DAM
TRAIL OF TEARS STATE PARK
CAPE GIRARDEAU COUNTY, MISSOURI
MISSOURI INVENTORY NO. 40008

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Crawford, Murphy & Tilly, Inc., Springfield, Illinois
A & H Engineering Corporation, Carbondale, Illinois

Under Direction Of

St. Louis District, Corps of Engineers

For

Governor of Missouri

FEBRUARY, 1981

PREFACE

This report is prepared under guidance contained in Department of the Army, Office of the Chief of Engineers, Recommended Guidelines For Safety Inspection Of Dams, for a Phase I investigation. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general conditions of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigation, testing and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. Additional data or data furnished containing incorrect information could alter the findings of this report.

It is important to note that the condition of the dam depends on numerous and constantly changing internal and external conditions and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Lake Boutin Dam
State Located: Missouri
Inventory Number: No. 40008
County Located: Cape Girardeau
Stream: Unnamed tributary to Flora Creek
Date of Inspection: 20 November 1980

BRIEF ASSESSMENT:

Lake Boutin Dam was inspected by a team of engineers from Crawford, Murphy & Tilly, Inc. of Springfield, Illinois and A & H Engineering Corporation of Carbondale, Illinois. The purpose of this inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers.

Lake Boutin Dam is an earthfill embankment constructed in the early 1960's across an unnamed tributary to Flora Creek. The dam is located in Trail of Tears State Park and is owned by the Missouri Department of Natural Resources, Division of Parks. The lake is used for recreation.

Based on the guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately three miles downstream of the dam. Located within this zone are a mobile home and several dwellings and outbuildings and Missouti State Route 177. The dam is in the intermediate size classification due to its height of 45.5 feet and maximum storage capacity of 485 acre-feet. Under the guideline classification, an intermediate size dam has a height greater than 40 feet but less than 100 feet and/or a maximum storage capacity greater than 1000 acre-feet but less than 50,000 acre-feet.

Our inspection and hydrologic and hydraulic analyses indicate that the spillway capacity of the dam does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The dam will hold and pass approximately 50 percent of the Probable Maximum Flood (PMF) without overtopping. The Probable Maximum Flood is defined as the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of intermediate size with a high downstream

hazard potential pass 100 percent of the PMF. The 1 percent probability flood (100-year flood) will not overtop the dam. The 1 percent probability flood is one that has a 1 percent chance of being equalled or exceeded in any given year.

The overall condition of the dam appeared to be poor and several deficiencies were noted during the inspection. Both the upstream and downstream faces of the dam have steep slopes of questionable stability. There is no drawdown facility at the dam. The spillway is a grass-lined channel and its crest is 0.7 feet below the top of the dam and has a limited capacity of approximately 10 cfs when the lake level reaches the top of the dam. The dam and spillway channel both consist of a clayey silt which is highly erodable material if it is not protected by vegetation or other means. Minor surface sloughing has occurred at several locations on the downstream face and the left slope of the spillway channel has sloughed into the channel. There is poor vegetal cover on much of the downstream face and there are numerous erosion gullies on the downstream face and in the emergency spillway channel. A concrete gutter along the downstream slope of the right abutment has been undermined, is cracked, and has several holes in it. Another deficiency is the lack of seepage and stability analysis records.

It is recommended that the owners take the necessary action without undue delay to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

Nathan Wilcoxon, P.E.
Crawford, Murphy & Tilly, Inc.

Guy Freese, P.E.
A & H Engineering Corporation

Timothy P. Tappendorf, E.I.T.
Crawford, Murphy & Tilly, Inc.

PHOTOGRAPH 1. OVERVIEW OF LAKE BOUTIN DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
LAKE BOUTIN DAM
MISSOURI INVENTORY NO. 40008

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APPENDICES

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Lake Boutin Dam located in Trail of Tears State Park, Cape Girardeau County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, "Recommended Guidelines For Safety Inspection Of Dams." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

Lake Boutin Dam is an earthfill structure approximately 45.5 feet high and 674 feet long at the crest. The dam has no drawdown facilities and the spillway is a trapezoidal channel cut into natural ground at the left abutment. In this report right and left orientation are based on looking in the downstream direction.

B. Location:

The dam is located in Trail of Tears State Park in Cape Girardeau County, Missouri on an unnamed tributary to Flora Creek. The longitude of the dam is 89° 29.3' West and the latitude is 37° 27.1' North. The dam and watershed are located in Section 15, Township 32 North, Range 14 East which is within the Ware, Illinois - Missouri 7.5 minute quadrangle map. Included in Appendix A are a location map for the dam on Plate 1 and a vicinity map on Plate 2.

C. Size Classification:

Lake Boutin Dam has an embankment height of approximately 45.5 feet and a maximum storage capacity of approximately 485 acre-feet. Therefore the dam is in the intermediate size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has classified this dam as a potential high hazard dam. The estimated damage zone extends approximately three miles downstream of the dam. Located within this zone are a mobile home, several dwellings and outbuildings, and Missouri Route 177. The affected items within the damage zone were verified by the inspection team.

E. Ownership:

The dam is owned by the Missouri Department of Natural Resources, Division of Parks, P. O. Box 176, Jefferson City, Missouri 65102, telephone (314) 751-2479. The superintendent of Trail of Tears State Park at the time of the inspection was Mr. John Bufkin, telephone (314) 334-1711.

F. Purpose of Dam:

The dam was constructed for recreation in Trail of Tears State Park.

G. Design and Construction History:

No records of the design or construction of Lake Boutin Dam could be found. According to Mr. Ken Oidtman of the Missouri Department of Natural Resources, no information concerning Lake Boutin Dam could be found in their files with the exception of a plan sheet showing the layout of the facilities surrounding the lake. Mr. Oidtman reported that the dam was probably designed by employees of the State Park Board which later became part of the Department of Natural Resources.

Mr. John Bufkin was interviewed following the inspection and a copy of a previous inspection report was obtained from him. Mr. Bufkin thought that the dam was constructed in the early 1960's. He knew of no modifications which have occurred to the dam since its construction.

H. Normal Operating Procedures:

There is no operating equipment at Lake Boutin Dam. Maintenance is the responsibility of the Park Superintendent of Trail of Tears State Park. According to the current Park Superintendent, John Bufkin, the crest of the dam is mowed about every two weeks during the growing season. Because of the steepness of the upstream and downstream slopes, they cannot be mowed with a power mower but any weeds and brush that grow on the upstream slope are trimmed by hand periodically. Any trees that begin to grow on the downstream face of the dam are cut down.

According to Mr. Bufkin the dam has never been overtopped and as far as he knows there has never been any flow in the spillway. The lake level has been controlled by rainfall, runoff, evaporation, and seepage of the lake water into the ground. No evidence of overtopping was noticed during the inspection.

1.3 PERTINENT DATA:

A. Drainage Area (Acres):	78
B. Discharge at Damsite (CFS):	
Maximum known flood at damsite	Not known
Drawdown facility capacity at maximum pool	Not applicable
Principal spillway capacity at maximum pool	10
Emergency spillway capacity at maximum pool	Not applicable
Total spillway capacity at maximum pool	10
C. Elevation (Ft. Above MSL):	
Top of dam	554.9
Streambed at downstream toe of dam	509.4
Normal pool	Fluctuates with evaporation, rainfall and seepage
Spillway crest	554.2
Pool elevation during inspection 11/20/80	545.0
Apparent high water mark	548.4
Maximum tailwater	Unknown
D. Reservoir Lengths (Feet):	
At top of dam	2300
At spillway crest	2250
At emergency spillway crest	Not applicable
E. Storage Capacities (Acre-Feet):	
At top of dam	485
At spillway crest	465
At emergency spillway crest	Not applicable
At pool level during inspection 11/20/80	245
At elevation of apparent high water mark	320

F. Reservoir Surface Areas (Acres):

At top of dam	28.2
At spillway crest	28.0
At emergency spillway crest	Not applicable
At pool level during inspection 11/20/80	19.0
At elevation of apparent high water mark	23.0

G. Dam:

Type		Earthfill embankment
Length of crest (feet)		674
Height (feet)		45.5
Top width (feet)		18
Side slopes (Horiz.:Vert.)	Upstream	1.6:1
	Downstream (See cross section of dam on Plate 5, Appendix A)	Varies from 1.4:1 to 3.3:1
Zoning		Unknown
Impervious Core		Unknown
Cutoff		Unknown
Grout curtain		Unknown

H. Diversion and Regulating Tunnel: None known

I. Spillway:

I.1 Principal Spillway:

Location	Immediately left of the left abutment
Type	Grass-lined, excavated trapezoidal channel
Crest elevation (feet above MSL)	554.2
Effective length of weir (feet)	10

Channel U/S of control section	Approx. 75' long; 6% slope
Control section	Approx. 50' long; 0% slope
Channel D/S of control section	Approx. 150' long; 5% slope for the first 50'; 9.5% slope for remaining 100'
Side slopes	Irregular (See cross sections on Exhibit 5 of Appendix B)

I.2 Emergency Spillway: None

J. Regulating Outlets: None

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

No engineering design data could be found for Lake Boutin Dam.

A. Surveys:

No detailed surveys have been made of the dam to our knowledge.

B. Foundation and Embankment Design:

No foundation and embankment design computations were available.

C. Hydrology and Hydraulics:

No hydrologic or hydraulic design computations were available.

2.2 CONSTRUCTION:

No construction inspection information or other construction data were available for the dam. It could not be determined who constructed the dam.

2.3 OPERATION:

There are no operating facilities at the dam.

2.4 EVALUATION:

A. Availability:

No engineering data, seepage or stability analyses, hydrologic or hydraulic analyses, or construction inspection data were available.

An engineering geologic report for Lake Boutin was done in February, 1978 by David Hoffman, Geologist, P.E., of the Applied Engineering and Urban Geology, Geology and Land Survey, of the Missouri Department of Natural Resources. A copy of it was obtained from Trail of Tears State Park Superintendent John Bufkin following the inspection, and is reprinted in Appendix D.

B. Adequacy:

Due to the fact that no engineering data were available, a detailed assessment of the design, construction, and operation of this structure could not be made. The fact that no seepage and stability analyses comparable to the requirements of the Recommended Guidelines for Safety Inspection of Dams were available is a deficiency which should be rectified. The seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

No conclusions can be drawn concerning the validity of the original design analyses due to unavailability.

The engineering geologic report done by David Hoffman in February, 1978 appeared to be valid. The report was obtained after this inspection was performed; therefore the specific problem areas noted in the report were not specifically examined. The holes and cracks noted in the report were not observed but they may have been repaired or hidden by the brush and weeds on the downstream face. The roughness and varying slope of the downstream face and the spillway condition mentioned in the report were observed and are discussed in Section 3 of this report. No seepage through the dam was noted and no evidence was found to indicate that the lake was leaking.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on 20 November, 1980. The inspection team consisted of personnel from Crawford, Murphy & Tilly, Inc. of Springfield, Illinois and from A & H Engineering Corporation of Carbondale, Illinois. The members were:

Nathan Wilcoxon, P.E. - Crawford, Murphy & Tilly, Inc.
Guy Freese, P.E. - A & H Engineering Corporation
Timothy Tappendorf, E.I.T. - Crawford, Murphy & Tilly, Inc.

The field inspection included the determination of dimensions and elevations of the dam and appurtenances necessary to show as a minimum a plan view, a dam profile, a spillway profile and section, and pertinent cross sections of the dam. For this report all elevations were obtained by using a USGS second order benchmark located near the dam. The benchmark is designated "UE14A" and is a punched hole in the top of the northwest end of a 24-inch circular metal culvert under the entrance drive to Trail of Tears State Park off of Missouri Route 177 just south southwest of Lake Boutin Dam. The elevation of the benchmark is 528.21 feet above Mean Sea Level. The benchmark can be seen in Photograph 15 of Appendix C. A visual inspection of the dam, spillway, drainage area, and downstream channel was performed and photographs were taken of each of them.

No one accompanied the inspection team during the inspection. Mr. John Bufkin, the Park Superintendent, was interviewed after the inspection was performed. He had been the superintendent for only a few years. Information was also obtained by phone conversations and correspondence with Mr. Ken Oidtman of the Missouri Department of Natural Resources.

Maps and general drawings of the dam and appurtenances are presented on Plates 1 through 5 in Appendix A and a hydrologic and hydraulic analysis is presented in Appendix B. Photographs of the dam and appurtenances are presented in Appendix C.

B. Regional and Project Geology:

The general southeastern Missouri area is underlain wholly or partially by Coastal Plain sediments. The Ozark Escarpment, which is the northwestern boundary, divides the lowland area from the Ozark Province. This is an irregular boundary which trends northeast by southwest from the southern sections of Cape Girardeau County through Bollinger County, Wayne County, Butler County and into Arkansas. All of Scott County, Stoddard County, Dunklin County, New Madrid County, Mississippi County and Pemiscot County (of the Mississippi embayment) are underlain by sediments of the Ozark Escarpment.

The Mississippi embayment is a broad arm of the Gulf Coastal Plain which extends up the Mississippi River Valley from the Gulf of Mexico. The outer rim of this embayment is outlined by outcrops of consolidated Paleozoic sediments. The embayment is structurally a downwarped, spoon-shaped trough

developed on the Paleozoic rocks. Unconsolidated to poorly consolidated sediments of Mesozoic and Cenozoic ages have been deposited in this trough (whose axis trends N30°E and is roughly marked by the course of the Mississippi River). The surface altitude of the Ozark Escarpment ranges from 335 to 240 feet.

The most prominent topographic features of the embayment are the Benton Hills of northern Scott County and southern Cape Girardeau County and Crowleys Ridge of Central Stoddard County and northern Dunklin County. Several flat-topped terraces (20 - 30 feet above lowland elevations) are present in the embayment area.

Cape Girardeau County lies in southeast Missouri, at the edge of the Ozark Province (along the Ozark Escarpment). The border of the Province runs along the southern border of Cape Girardeau County and turns northward along the Mississippi River. The southern edge of Cape Girardeau County lies within advance lowlands (of the embayment of southeastern Missouri). Hickory Ridge terrace lies within this region in the southwest corner of Cape Girardeau County. The subsurface geology of the southern sections of this county consist of Ordovician bedrock (Canadian, Smithville, Jefferson City, in the southwest, St. Peter, Everton in the south central and Kimmswick, Dutchtown in the southeast sections of the county). Tertiary - Quaternary deposits overlie most bedrock formations in this area. Silurian-Devonian bedrock is exposed along the Mississippi River from the east central up to and including most of the northeast sections of the county. These systems include the Girardeau, Brassfield, and Bainbridge formations of the Silurian system and the Bailey formation of the Devonian System. The central, northern and all of the western sections of this county are included in the Ozark Province, Ordovician bedrock belonging to the (Canadian) Roubidoux formation and the Kimmswick-Dutchtown formations, make up most of the subsurface deposits in this area.

The area around the dam site consists of exposed Silurian-Devonian bedrock overlying Ordovician bedrock. Silurian bedrock consists of the Girardeau, Brassfield, and Bainbridge formations which range from 100 to 400 feet. The Girardeau formation consists of a cherty, dense, dark gray limestone, usually about 40 feet thick and usually restricted to Cape Girardeau County. The Brassfield formation consists of gray limestone with glauconite at the top. This formation lies at the top of the Lower Silurian bedrock system. The Brassfield formation (of the Middle Silurian bedrock system) consists of red, argillaceous limestone ranging from 30 to 160 feet thick (a very distinct bed). Devonian bedrock consists of the Bailey formation, which is approximately 50 feet thick. This formation consists of a very cherty limestone with inner-bedded blue-green shale. The Mississippi River flood plain and valley lies directly east of the site. The exposed Paleozoic bedrock is subject to wind and stream erosion. Loess and stream alluvial deposits of the Quaternary system are common throughout all areas of the embayment area. The loess deposits range from 9 to 80 feet thick and are comprised of a yellow-brown silt. The alluvial deposits range from 10 to 275 feet thick and consist of sand, gravel, some clay and traces of lignite.

C. Dam:

Lake Boutin Dam is an earthfill dam with a height of approximately 45.5 feet and length at the crest of approximately 674 feet. The spillway is a trapezoidal channel cut into natural ground just left of the left abutment. There is no emergency spillway or drawdown facility at the dam. There is a concrete gutter beginning at the crest and running along the junction of the right abutment and the downstream face of the dam. The upstream slope of the dam has riprap for wave erosion protection. The overall condition of the dam appeared to be poor.

Both vertical and horizontal alignment of the crest of the dam appear fairly uniform. The horizontal alignment of the crest is a straight line and the crest has a width of approximately 18 feet.

The elevation of the centerline of the crest of the dam varies from 554.9 to 556.3. Although there is a 1.4 foot variation in the crest elevation the vertical alignment reveals no major problem. Most of the variation was apparently caused by greater settlement near the center of the dam compared to the ends of the dam due to the greater height of the embankment near its center.

The profile of the crest of the dam is shown on Exhibit 4 of Appendix B. The upstream face of the dam is uniform except for a slight change in slope at the top of the riprap. The downstream face of the dam has a varying slope with the steepest slope of about 1.4 horizontal to 1 vertical just below the crest and a slope of about 3.3 horizontal to 1 vertical near the toe of the dam. A typical cross section of the dam can be seen on Plate 5 of Appendix A.

Minor surface sloughing has occurred at many localized locations on both the upstream and downstream slopes of the dam, but the varying slope of the downstream face does not appear to be the result of sloughing. The small sloughs are at the surface with a maximum depth of about 12 inches and are apparently due to the steepness of the slopes, especially near the crest. No surface cracks or unusual movement or cracking at or beyond the toe of the dam was noticed. No evidence was found of animal holes or burrows on the embankment. The crest and the upstream face of the dam above the riprap have a good cover of fescue grass which is mowed regularly and can be seen in Photographs 2 and 3. There are numerous erosion gullies with an approximate depth of 12 inches on the downstream face of the dam. There are also several erosion gullies beyond the toe of the embankment. No evidence of seepage from the dam was found and no drains were observed. The surface cover on the downstream face of the dam consists of a sparse cover of brush and weeds from the right abutment to about the center of the dam and consists of fescue grass and weeds from the center of the dam to the left abutment. The downstream slope can be seen in Photograph 4. The downstream face of the dam has not been mowed, apparently due to its steepness, and the visual inspection of it was difficult due to the tall brush, grass, and weeds. There are no trees on the dam but there are several rows of oak trees that were planted just beyond the toe of the dam.

There is a paved gutter at the right abutment on the downstream slope which carries surface runoff from the crest to beyond the toe of the dam. This gutter has been undermined apparently along its entire length and has many cracks and several holes in the concrete as seen in Photographs 9 and 10. There is an erosion gully which is approximately 3 feet deep at its deepest point located on the hillside just downstream of the left abutment. It can be seen in Photograph 11. Riprap lined the upstream face of the dam from elevation 547.6 to just below the water surface on the day of inspection which was at elevation 545.0. The riprap consists of 4-inch to 12-inch diameter stone and is rather sparse the entire length of the dam, but erosion from wave action is minimal. The riprap can be seen in the overview photograph at the beginning of this report and on Photograph 2.

A shallow soil sample was obtained from the embankment near the center of the crest. The sample was classified as a light brown clayey silt (ML).

D. Appurtenant Structures:

D.1 Principal Spillway:

The principal spillway is a channel cut into a hillside just left of the left abutment. The channel is approximately perpendicular to the dam crest and extends about 175 feet upstream from the centerline of the dam and about 125 feet downstream of the centerline before exiting the channel and flowing on natural ground again. There is a ridge of ground which separates the spillway channel from the dam. This ridge is part of the original hillside which was not cut away when the channel was made.

A profile of the centerline of the spillway is shown on Exhibit 5 of Appendix B. A cross section of the spillway channel at its control section and a cross section of the spillway discharge channel at the centerline of the dam are both shown on Exhibit 6 of Appendix B.

The elevation of the crest of the spillway is approximately 554.2 while the elevation of the low point of the dam is approximately 554.9. Since there is only 0.7 feet of freeboard between the crest of the spillway and the low point of the dam, the spillway has an approximate capacity of only 10 cfs when the lake level is at the top of the dam. According to Park Superintendent John Bufkin there has never been any flow in the spillway and the apparent high water mark at elevation 548.4 confirmed that.

The spillway approach channel, crest and discharge channel can be seen in Photographs 6, 7 and 8 respectively. The approach channel is not well defined and has a nonuniform slope and also has several small trees in it. The approach channel has several erosion gullies and one gully had apparently been blocked and contained standing water apparently from recent precipitation the area had received. The crest and discharge channel both have a thick cover of grass and weeds but there are several erosion gullies on both of them with a gully near the downstream end of the discharge channel being several feet deep. There is a rock outcropping in the floor of the downstream channel of the spillway. The left slope of the channel has sloughed

off and filled in part of the original channel. This sloughed area also has numerous erosion gullies caused by surface runoff from the hillside above it. The sloughed area and hillside can be seen in Photograph 5.

D.2 Emergency Spillway:

There is no emergency spillway associated with this dam.

E. Reservoir and Watershed:

The watershed for Lake Boutin contains the lake surface area, recreational areas, and heavily forested areas. The surface area of the lake is a substantial portion of the total drainage area, being approximately 25% at elevation 545.0 which was the water level the day of the inspection and ranging up to 36% at the top of the dam elevation of 554.9. About half of the remainder of the drainage area is used for recreational purposes consisting of picnic areas and a beach. Most of this recreational area has a short grass cover with a few trees and has average slopes of 10 to 15%. Approximately 10% of this recreational area consists of an impervious roadway and parking lot. A view of the lake and some of the recreational area surrounding it is given in Photograph 12. The remainder of the drainage area consists of heavy forest on average slopes of 15 to 20%. A typical view of this area is given in Photograph 13.

About half the watershed has soil belonging to the Clarksville Series and half belongs to the Menfro Series. Both soils are in hydrologic Group B as defined by S.C.S. Sedimentation of the reservoir is very minor. The thick forest and grass seem to hold the soil and the relatively large lake area compared to the size of the watershed make the effect of sedimentation minor.

F. Downstream Channel:

The channel just downstream of the spillway discharge channel is a V-shaped ditch with a tall grass cover with some brush and small trees. This ditch extends approximately 500 feet at an average slope of 12% and then there is a 5.6 feet high by 4.7 feet wide corrugated metal pipe arch through the embankment on which Missouri Route 177 is built. Downstream from Route 177 the channel is trapezoidal and heavily wooded along each bank and extends approximately 1.5 miles at an average slope of 0.7% before its confluence with Flora Creek.

3.2 EVALUATION:

A number of deficiencies exist which should be corrected. The steep slopes, the unusual breaks in the downstream slope, and the fact that the dam is located in Seismic Zone 3 make the dam's seismic stability questionable. The lack of a seepage and stability analysis, including seismic loading, is a deficiency which should be corrected.

Erosion and sloughing problems exist on both the downstream face of the dam and in the spillway channel. A better vegetal cover should be started after all of the erosion gullies have been repaired. Flattening of some slopes may be necessary to control sloughing. The concrete gutter at the right abutment should be repaired to control further undermining.

The capacity of the spillway should be increased as discussed in Section 5, and means provided to control erosion in the discharge channel.

The engineering geologic report by David Hoffman which is reprinted in Appendix D pointed out several possible problems. The roughness and varying slope of the downstream face of the dam and the potential erosion problem in the spillway were verified. The cracking and holes in the dam and the leaking of the lake were not noticed during the inspection. No seepage was noticed near the dam and no evidence of leakage other than the normal movement of lake water into the groundwater table was noticed. It is not known what corrective measures or monitoring has taken place at the dam as a result of the Hoffman engineering geologic report. Mr. John Bufkin was not the Park Superintendent when the Hoffman report was done. He did not indicate that a regular monitoring of the dam was being done but that he looked at the dam when he drove by it. No significant changes were noted in the condition of the dam from that reported in the Hoffman report.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

There is no operating equipment at Lake Boutin. The water level has been controlled by rainfall, runoff, evaporation, and seepage of the lake water into the ground. Should the lake level ever reach the spillway crest, there will be outflow from the lake through the spillway channel.

4.2 MAINTENANCE OF DAM:

The maintenance of the dam is the responsibility of the Park Superintendent of the Trail of Tears State Park. The present Superintendent, John Bufkin, said that maintenance of the dam is performed regularly. The crest of the dam is mowed about every other week during the growing season. The upstream and downstream slopes are too steep to be mowed with the equipment available to the park personnel. The upstream face is trimmed with hand tools periodically and any small trees that begin to grow on either the upstream or downstream slopes are cut off each year. No maintenance of the spillway channel has been done recently.

4.3 MAINTENANCE OF OPERATING FACILITIES:

There are no operating facilities at the dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

No warning system is known to exist.

4.5 EVALUATION:

Maintenance of the dam should be improved. Erosion gullies on the dam and in the spillway should be repaired and reseeded. The small trees in the spillway should be removed. The practice of cutting down trees that begin to grow on the dam should be continued. The downstream slope needs to be cleared of brush and weeds and seeded to grass. It should be mowed regularly to promote a good grass cover and to keep weeds and brush from growing extensively. The spillway channel should also be mowed regularly.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

No hydrologic or hydraulic design computations for Lake Boutin Dam and its watershed are available.

The significant dimensions of the dam and reservoir were measured or surveyed on the date of inspection or estimated from available topographic mapping. The map used in the analysis is the 7.5 minute U.S. Geological Survey quadrangle sheet for Ware, Illinois - Missouri, dated 1947 and photo revised 1978. Surface soil information was available from a map obtained from the Cape Girardeau County Soil Conservation Service office.

B. Experience Data:

No recorded rainfall, runoff, discharge, or reservoir stage data were available for the lake and watershed. Information received from John Bufkin indicated that there has never been outflow from the lake through the spillway.

C. Visual Observations:

A description of the watershed and reservoir is given in Paragraph 3.1 E and a description of the spillway is given in Paragraph 3.1 D1. The lake level has apparently been controlled in the past by rainfall, runoff, evaporation, and seepage of the lake water into the ground. An apparent high water mark was observed and found to be 5.8 feet below the crest of the spillway. The crest of the spillway is only 0.7 feet below the low point of the dam and the spillway has a capacity of about 10 cfs before overtopping of the dam would begin.

A description of the downstream channel is given in Paragraph 3.1 F. The downstream hazard zone extends approximately 3 miles downstream from the dam and includes a mobile home and several dwellings and outbuildings. Also Missouri Route 177 is in the hazard zone and crosses the downstream channel several times.

D. Overtopping Potential:

Based on the hydrologic and hydraulic analysis presented in Appendix B, the dam and its spillway have the capacity to store and pass approximately 50 percent (to the nearest 5 percent) of the Probable Maximum Flood (PMF) before being overtopped. The Probable Maximum Flood is defined as the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in a region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this dam which is in the intermediate size

category with a high downstream hazard potential classification pass 100 percent of the PMF without overtopping. Thus the spillway capacity of this dam is considered inadequate. The dam and spillway will hold and pass a 1 percent probability flood without overtopping the dam.

Data for the 50 percent PMF and the 100 percent PMF is presented in the table below.

Percent PMF	Starting Pool Elevation (MSL)	Peak Inflow To Lake (cfs)	Maximum Pool Elevation (MSL)	Maximum Depth Over Dam (feet)	Peak Discharge (cfs)	Overtopping Duration (hour)
50%	550.7	739	554.7	0	5	0
100%	552.8	1478	555.9	1.0	1129	10+

The starting pool elevations shown were found by assuming the lake level was at the apparent high water mark of 548.4 and then applying an appropriate antecedent storm to the watershed 4 days prior to the storm being analyzed. The antecedent storm for the 50% PMF was a 25% PMF and the antecedent storm for the 100% PMF was a 50% PMF.

All of the inflow to the lake from the antecedent storms is stored in the lake and results in the starting elevations above the apparent high water mark for the analysis of the 50% and 100% PMF.

There is only 0.7 feet of freeboard between the spillway crest and the low point of the dam. The spillway has a capacity of about 10 cfs when the lake level is at the low point of the dam. The depths and velocities of flow in the spillway channel obtained when the lake level is at or below the low point of the dam are expected to cause only minor erosion in the spillway channel.

It should be noted that the level of the lake in the past has been controlled by rainfall, runoff, evaporation, and seepage of water into the ground water table. The lake has the ability to hold and pass a storm the magnitude of the 50% PMF when the lake level before the storm is at elevation 550.7. Should the lake level reach an elevation greater than 550.7, the percentage of the PMF that it will be able to hold and pass will be less than 50%. It should be realized that as the elevation of the lake increases, the magnitude of the storm that the dam will hold and pass decreases. The lake level should be monitored and should the lake level approach the spillway crest the downstream residents should be warned of the increased chance of overtopping of the dam and its potential failure.

Overtopping of Lake Boutin Dam could cause serious erosion and could possibly lead to failure of the structure. Flood discharges resulting from a failure of Lake Boutin Dam could be expected to produce substantial stage rises in the hazard zone. Overtopping would lead to potential loss of life and potential extensive damage to Route 177.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Section 3 of this inspection report.

B. Design and Construction Data:

Design data were unavailable.

Seepage and stability analyses comparable to the requirement of the inspection guidelines were also not available. This situation constitutes a deficiency which should be corrected. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

No significant post-construction changes were observed or known.

E. Seismic Stability:

This dam is located in Seismic Zone 3, as shown on Plate 3 of Appendix A. Zone 3 delineates areas in which major damage would result from the expected seismic activity in this area. An accurate slope stability analysis with seismic loading cannot be made because of the lack of original design data and soil strength parameters. It should be noted that due to the relatively steep embankment slopes, in the event of potential seismic loading the slopes may become unstable and suffer damage, possibly severe.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

A. Safety:

Several items were noticed during the field inspection that could adversely affect the safety of the dam. These items are: (1) poor vegetal cover, surface sloughing, and erosion gullies on the downstream face of the dam; (2) sloughing of the left slope of the spillway channel and erosion in the spillway channel; (3) the presence of small trees in the spillway channel; (4) undermining of the gutter at the right abutment on the downstream slope.

Another deficiency was the lack of seepage and stability analyses. This deficiency should be corrected, especially in light of the steep slopes.

The dam will be overtopped by flows in excess of approximately 50 percent of the Probably Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

It should be noted that the level of the lake in the past has been controlled by rainfall, runoff, evaporation, and seepage of water into the ground water table. The lake has the ability to hold and pass a storm the magnitude of the 50% PMF when the lake level before the storm is at elevation 550.7. Should the lake level reach an elevation greater than 550.7, the percentage of the PMF that it will be able to hold and pass will be less than 50%. It should be realized that as the elevation of the lake increases, the magnitude of the storm that the dam will hold and pass decreases. The lake level should be monitored and should the lake level approach the spillway crest the downstream residents should be warned of the increased chance of overtopping of the dam and its potential failure.

B. Adequacy of Information:

The conclusions in this report were based on the performance history as related by others, visual observation of external conditions, and data from available mapping. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the Recommended Guidelines for Safety Inspection of Dams were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in Paragraph 7.2 for the items concerning the safety of the dam noted in Paragraph 7.1A should be accomplished in the near future. The deficient items concerning the downstream slope and spillway channel should be given a high priority. If good maintenance is not provided, the embankment condition will continue to deteriorate and possibly could become serious in the future.

D. Necessity for Additional Inspection:

Based on the results of the Phase I inspection, additional periodic inspections are recommended.

7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

A. Recommendations:

(1) The hydraulic capability of this dam should be increased to safely hold and/or pass the recommended Spillway Design Flood which is 100 percent of the PMF. This is normally accomplished by one or more of the following alternative measures:

(a) Construction of additional erosion free spillway capacity.

(b) Provision for additional flood storage by:

i. Increasing the height of the dam.

ii. Permanently reducing the normal pool elevation.

(2) A seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams. Since the dam is located in Seismic Zone 3, the analyses should include seismic loadings.

(3) The embankment slopes are expected to be significantly affected by potential seismic loadings. Provisions should be made to properly stabilize the embankment slopes to prevent potential instability. Such work should be accomplished based upon the engineering analyses recommended in Item (2) above.

B. Operation and Maintenance Procedures

(1) Erosion gullies on the dam and spillway channel should be repaired and reseeded.

(2) The undermined gutter at the downstream right abutment should be repaired.

(3) The weeds and brush on the downstream slope should be removed and a better vegetal cover should be grown.

(4) The small trees in the spillway channel should be removed. Any trees that begin growing on the dam or in the spillway channel in the future should be removed.

(5) The left bank of the spillway channel should be stabilized.

(6) The dam should be monitored for further erosion in the future and repaired as necessary.

(7) The upstream face of the dam should be monitored for further erosion due to wave action and additional slope protection added if necessary.

(8) Any animals that begin burrowing in the embankment should be removed and their burrows filled.

(9) The dam should be periodically inspected by an experienced engineer and records kept of these inspections and maintenance efforts.

PHASE I INSPECTION REPORT

APPENDIX A

MAPS AND GENERAL DRAWINGS

APPENDIX A

MAPS AND GENERAL DRAWINGS

TABLE OF CONTENTS

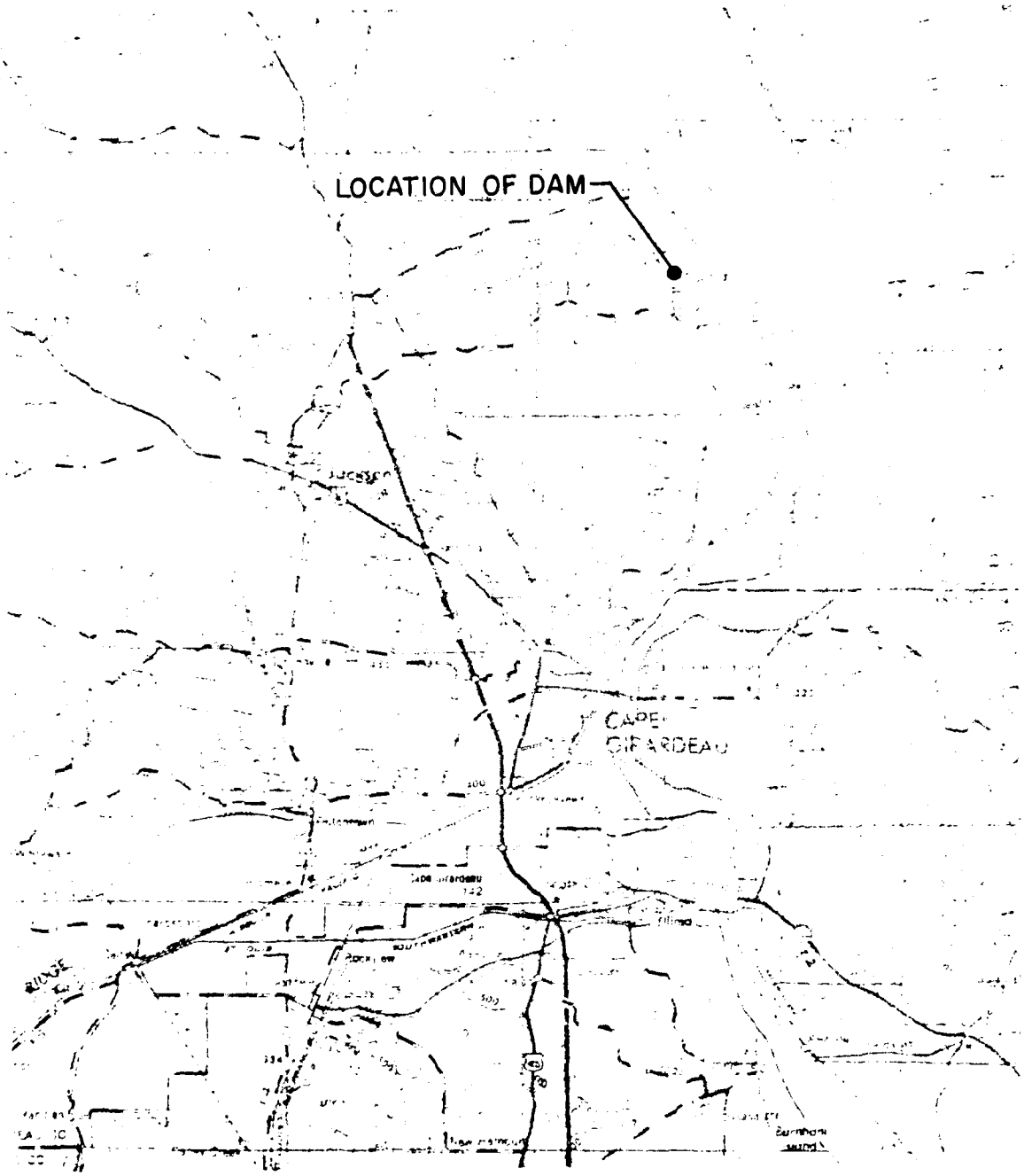
CRAWFORD MURPHY & TILLY, inc. Consulting Engineers
SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

LOCATION MAP

LAKE BOUTIN DAM MO40008

PLATE 1



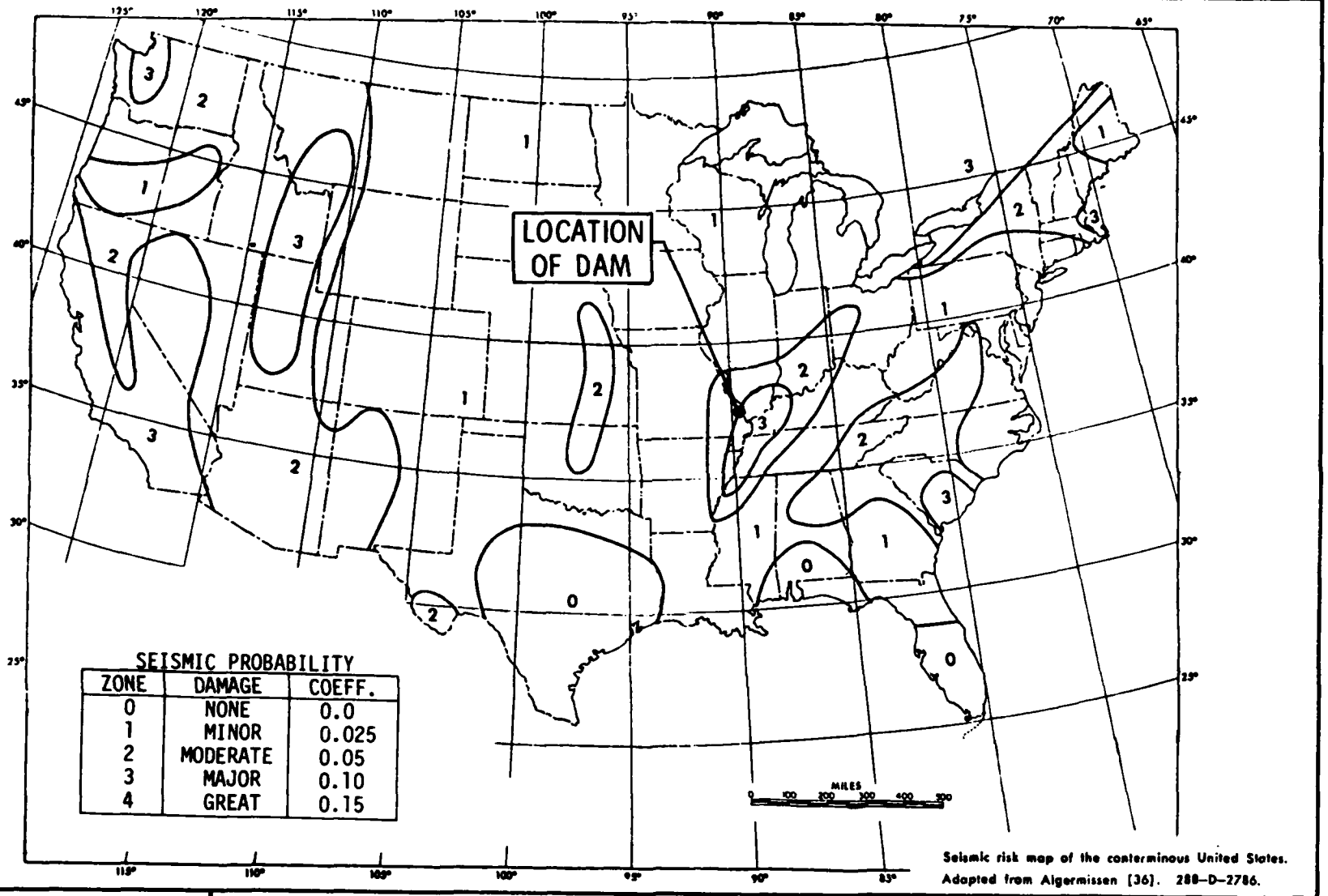
N

SCALE
1: 250,000

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

VICINITY MAP
LAKE BOUTIN DAM MO40008

PLATE 2



SEISMIC PROBABILITY

ZONE	DAMAGE	COEFF.
0	NONE	0.0
1	MINOR	0.025
2	MODERATE	0.05
3	MAJOR	0.10
4	GREAT	0.15

Seismic risk map of the conterminous United States. Adapted from Algermissen [36]. 288-D-2786.

PLATE 3

CRAWFORD MURPHY & TILLY, inc. Consulting Engineers
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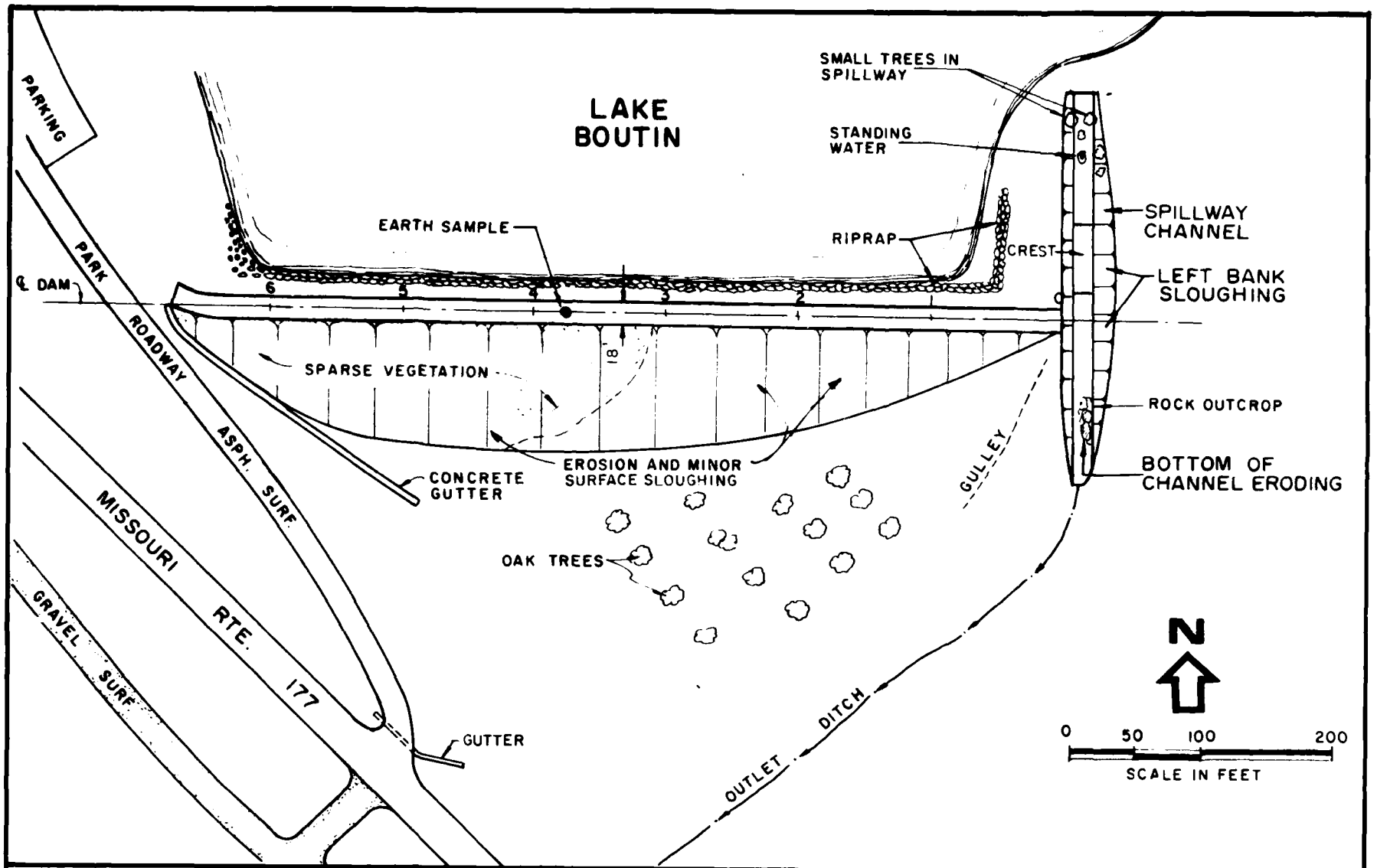
U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

SEISMIC ZONE MAP OF CONTIGUOUS STATES
LAKE BOUTIN DAM MO40008



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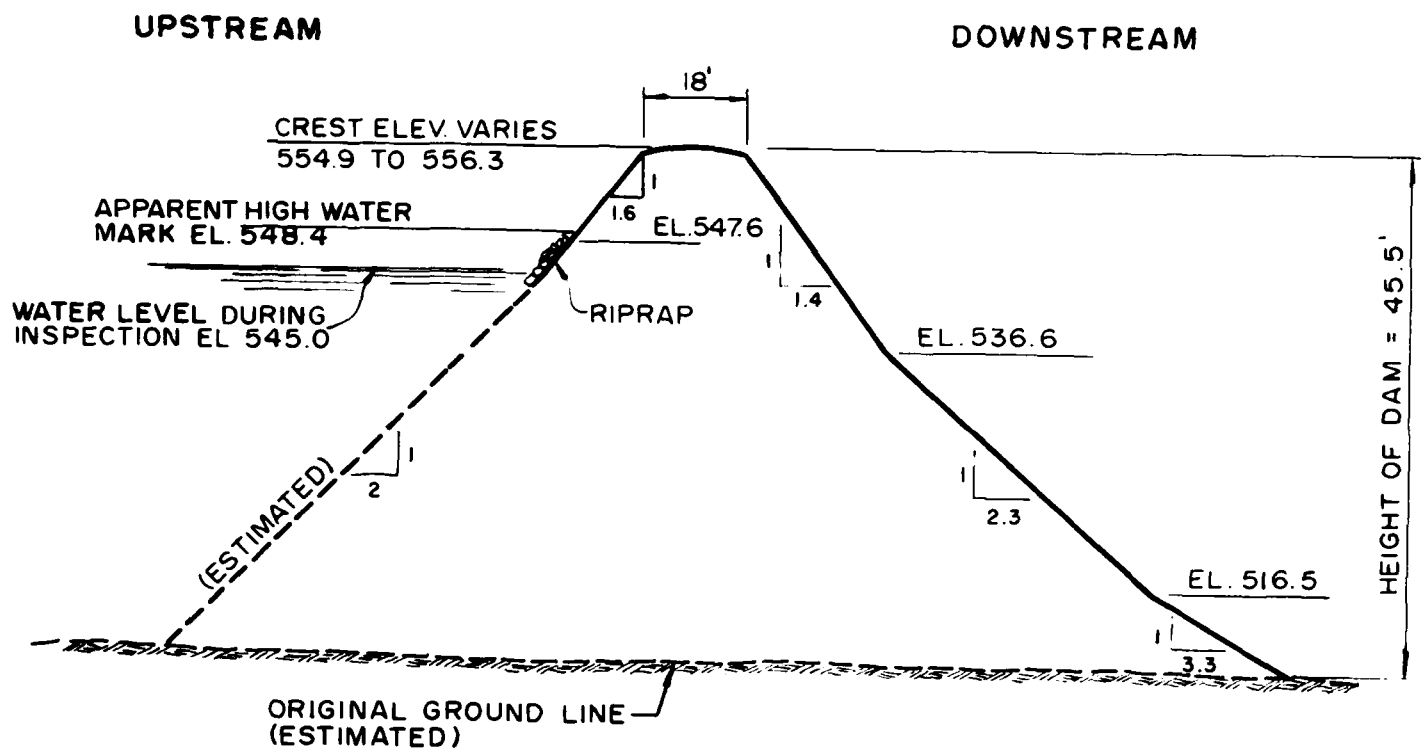
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

PLAN OF DAM AND SPILLWAY
LAKE BOUTIN DAM MO40008

PLATE 4



TYPICAL CROSS SECTION OF DAM

APPROXIMATE SCALE
HORIZ. 1" = 30'
VERT. 1" = 15'

CRAWFORD, MURPHY & TILLY, inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	CROSS SECTION OF DAM LAKE BOUTIN DAM MO40008

PLATE 5

PHASE I INSPECTION REPORT

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSIS

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSIS

TABLE OF CONTENTS

EXHIBITS

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSIS

A. PURPOSE:

The purpose of this Appendix is to present the methodology used and the results of the hydrologic and hydraulic analysis. The analysis was done according to criteria presented in the "Recommended Guidelines for Safety Inspection of Dams" and in the "St. Louis District Hydrologic/ Hydraulic Standards for Phase I Safety Inspection of Non-federal Dams" dated 22 August 1980. The purpose of the analysis is to determine the overtopping potential for Lake Boutin Dam.

B. HYDROLOGIC AND HYDRAULIC ANALYSIS:

The hydrologic analysis used in development of the overtopping potential is based on applying a hypothetical storm to a unit hydrograph to obtain the inflow hydrograph for a reservoir routing. Data for determination of the unit hydrograph was obtained from the U.S. Geological Survey 7.5 minute quadrangle map for Ware, Illinois - Missouri dated 194, and photorevised in 1978 and from the field inspection. A lake and watershed map is shown on Exhibit 1. The parameters used in the development of the unit hydrograph are presented in Table 1. A plot of the unit hydrograph is presented on Exhibit 2.

TABLE 1

UNIT HYDROGRAPH PARAMETERS

Drainage Area (A)	78 acres
Time of Concentration (Tc) - determined using overland plus channel flow times	10 minutes
Duration (smallest HEC-1 allows)	5 minutes
Peak Flow	265 cfs
Snyder's Lag (tp)	0.185 hours
Snyder's Peaking Coefficient (Cp)	0.67

Unit Hydrograph from the Computer Output

Time (Minutes)	Discharge (cfs)
0	0
5	67
10	208
15	265
20	188
25	97
30	50
35	26
40	13
45	7
50	4

The hypothetical storm that is applied to the unit hydrograph is the Probable Maximum Precipitation (PMP). It is derived and determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." No reduction factors have been applied to the PMP. A 1 percent probability storm was also analyzed. A 24-hour storm duration is assumed with total depth distributed over 6-hour periods in accordance with procedures outlined in EM 1110-2-1411 (SPF determination). The maximum 6-hour rainfall period is then distributed to hourly increments by the same criteria. Within-the-hour distribution is based upon NOAA Technical Memorandum NWS HYDRO-35. The non-peak 6-hour rainfall periods are distributed uniformly. All distributed values are arranged in a critical sequence by the SPF. The final inflow hydrograph is produced by deduction of infiltration losses appropriate to the soil, land use, and antecedent moisture conditions. Soil information was obtained from mapping available from the Cape Girardeau County Soil Conservation Service. Land use and slopes were determined from the field inspection and available mapping. Antecedent Moisture Condition II (AMC II) was used for the analysis of the 1 percent probability storm and AMC III was used for the analysis of the PMP percentage storms. The rainfall applied, the parameters used to determine infiltration losses and the resulting runoffs are presented in Table 2.

TABLE 2

RAINFALL-RUNOFF PARAMETERS

Selected Storm Event	Storm Duration (hours)	Rainfall (inches)	Runoff (inches)	Losses (inches)
PMP	24	34.56	32.61	1.95
1% Probability Storm	24	7.10	2.2	4.90

Additional Data:

1) Soil Conservation Service Runoff Curve Number CN = 79 (AMC III) for the PMF and 50% PMF
2) Soil Conservation Service Runoff Curve Number CN = 60 (AMC II) for the 1% probability storm
3) Percentage of Drainage Basin Impervious 35 percent

The reservoir routing is accomplished by using the Modified Puls routing technique where in the flood hydrograph is routed through lake storage. The hydraulic capacity of the spillway and the crest of the dam are used as outlet controls in the routing. Storage in the pool area is defined by an elevation-storage capacity curve. The hydraulic capacity of the spillway and top of the dam are defined by elevation-discharge curves.

The elevation-storage capacity curve was developed by determining the lake surface area at various elevations using available mapping and then inputting this information to the HEC-1 computer program. The computer

program then developed an elevation-storage capacity curve using the conic method. An Elevation-Area-Capacity curve is shown on Exhibit 3.

For the overtopping analysis the top of the dam is the lower of the following elevations: (1) The minimum elevation of embankment as determined by simple field surveys. (2) The lake elevation at which corresponding outflow velocities, as determined from simple hydraulic formula, exceed the suggested maximum permissible mean channel velocities. The top of the dam was determined to be 554.9 which is the minimum elevation of the embankment. Outflow velocities in the spillway when the lake is at this elevation are at or below the suggested maximum permissible mean channel velocities for grass-lined channels with silt clay soil. Therefore only minor erosion of the spillway channel is expected by flows when the lake level is at or below the top of the dam.

The elevation-discharge capacity curve for the top of the dam was developed using the non-level crest option of the HEC-1 computer program. The program assumes critical flow over a broad-crested weir. A profile of the dam crest is given on Exhibit 4.

The hydraulic capacity of the spillway was determined using methods found in the U.S. Department of Agriculture Soil Conservation Service Technical Release No. 2, "Earth Spillways," dated October 1, 1956. The profile of the spillway flow line and cross sections of the spillway channel as surveyed in the field were used in this determination and they are shown on Exhibits 5 and 6. The elevation-spillway capacity input to the computer is shown in Table 3.

TABLE 3

LAKE ELEVATION VS. SPILLWAY CAPACITY

Values Input To The HEC-1 Computer Program

Lake Elevation (MSL)	Spillway Capacity (cfs)
554.2	0
554.7	5
555.2	21
556.2	79
557.2	198
558.2	383

The dam overtopping analysis has been conducted by hydrologic methods for this dam and lake. This analysis determines the percentage of the PMF hydrograph that the reservoir can contain without the dam being effectively overtopped. According to "Hydrologic/Hydraulic Standards" developed by the Corps of Engineers, St. Louis District, an antecedent storm should be applied to the watershed before analysis of the PMF. The antecedent storm precedes the storm being analyzed by 4 days and the starting elevation at the beginning of the antecedent storm is the mean annual

high water mark. Since no mean annual high water mark could be determined for Lake Boutin, the observed apparent high water mark at elevation 548.4 was used as the starting elevation at the beginning of the antecedent storms. The antecedent storm for the analysis of the PMF ratio storms is one-half the storm being analyzed. There is enough storage capacity between the apparent high water mark elevation and the spillway crest elevation that all of the antecedent storms can be stored. The starting elevations, antecedent storms, and storms analyzed are given in Table 4.

TABLE 4

ANTECEDENT STORMS AND STARTING ELEVATIONS

Starting Elevation Before Antecedent Storm	Antecedent Storm Used	Elevation At Start of Storm Being Analyzed	Storm Being Analyzed
548.4	25% PMF	550.7	50% PMF
548.4	50% PMF	552.8	100% PMF

The above methodology has been accomplished for this report using the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. The numeric parameters estimated for this site for the 50% PMF and input to the program are listed on Exhibit 7. Definitions of these variables are contained in the "User's Manual" for the computer program.

The inflow and outflow hydrographs, obtained from the computer output, for the 50% and 100% PMF storms are shown on Exhibits 8 and 9. A summary table for the overtopping analysis is presented on Exhibit 10 for the 50% PMF and on Exhibit 11 for the 100% PMF.

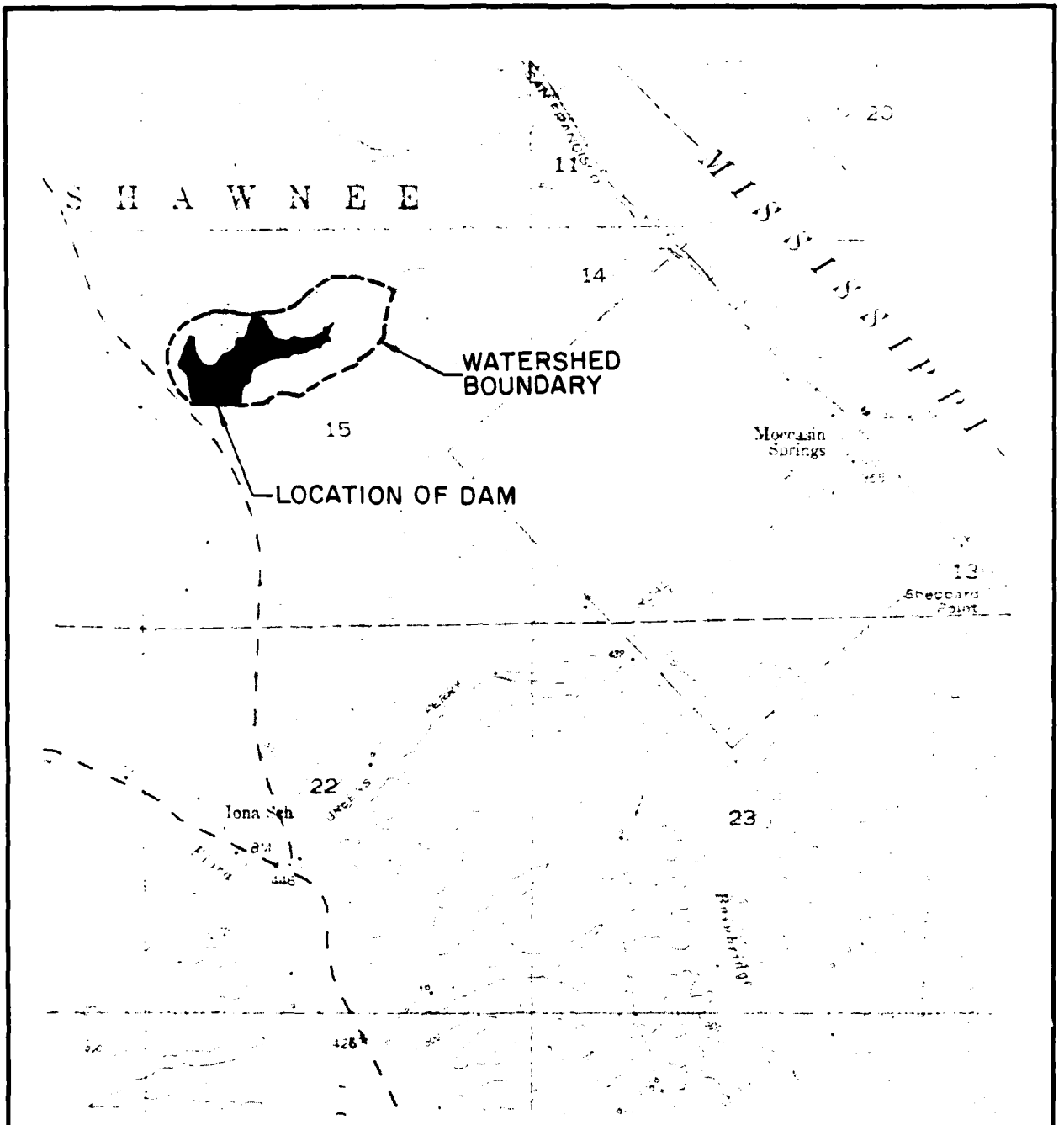
C. REFERENCES:

a. Earth Spillways, Technical Release No. 2, Soil Conservation Service, United States Department of Agriculture, Engineering Division, October, 1956.

b. Flood Hydrograph Package (HEC-1), Users Manual for Dam Safety Investigations, The Hydrologic Engineering Center, U. S. Army Corps of Engineers, Davis, California; September, 1978.

c. National Engineering Handbook, Sec. 4 - Hydrology, Supplement A; Soil Conservation Service, United States Department of Agriculture, 1957.

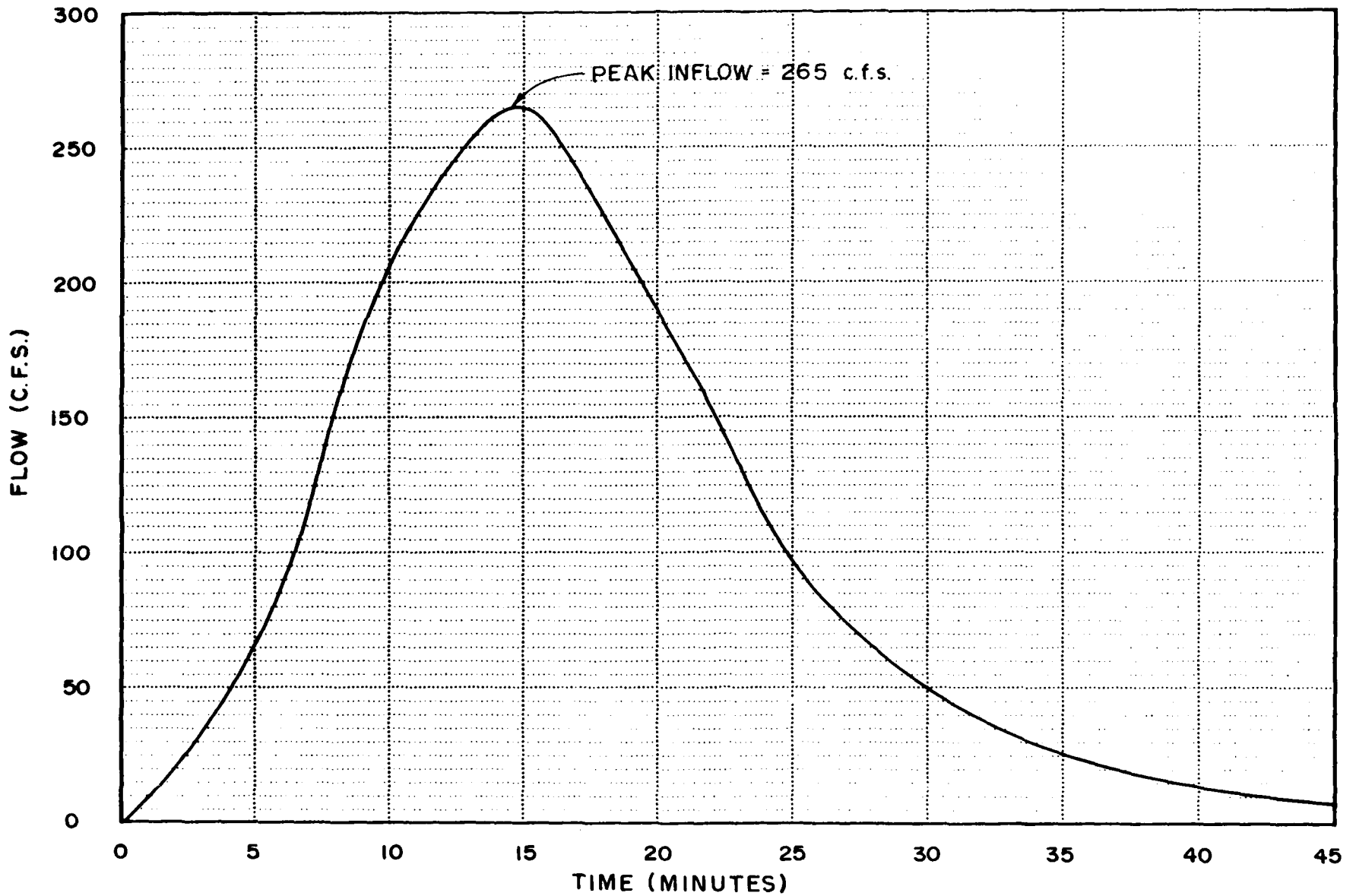
d. Riedel, J. T., Appleby, J. F., and Schloemer, R. W., Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1000 Square Miles and Durations of 6, 12, 24 and 48 Hours, Hydrometeorological Report No. 33, U. S. Department of Commerce, Weather Bureau, April 1956.



CMS	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	LAKE AND WATERSHED MAP LAKE BOUTIN DAM MO40008

EXHIBIT 1

EXHIBIT 2



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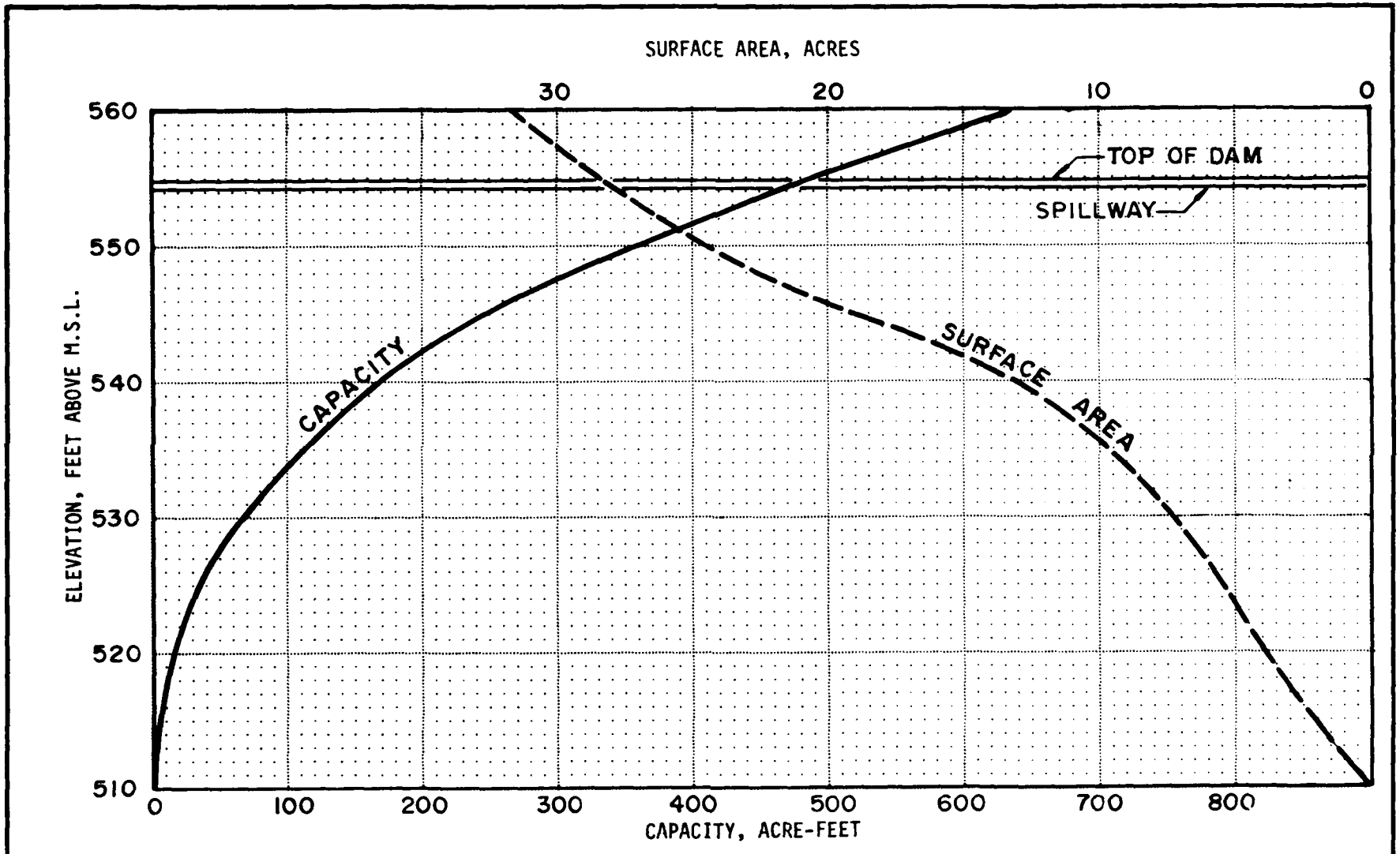

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CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

ELEVATION - AREA - CAPACITY RELATION
LAKE BOUTIN DAM MO40008

EXHIBIT 3

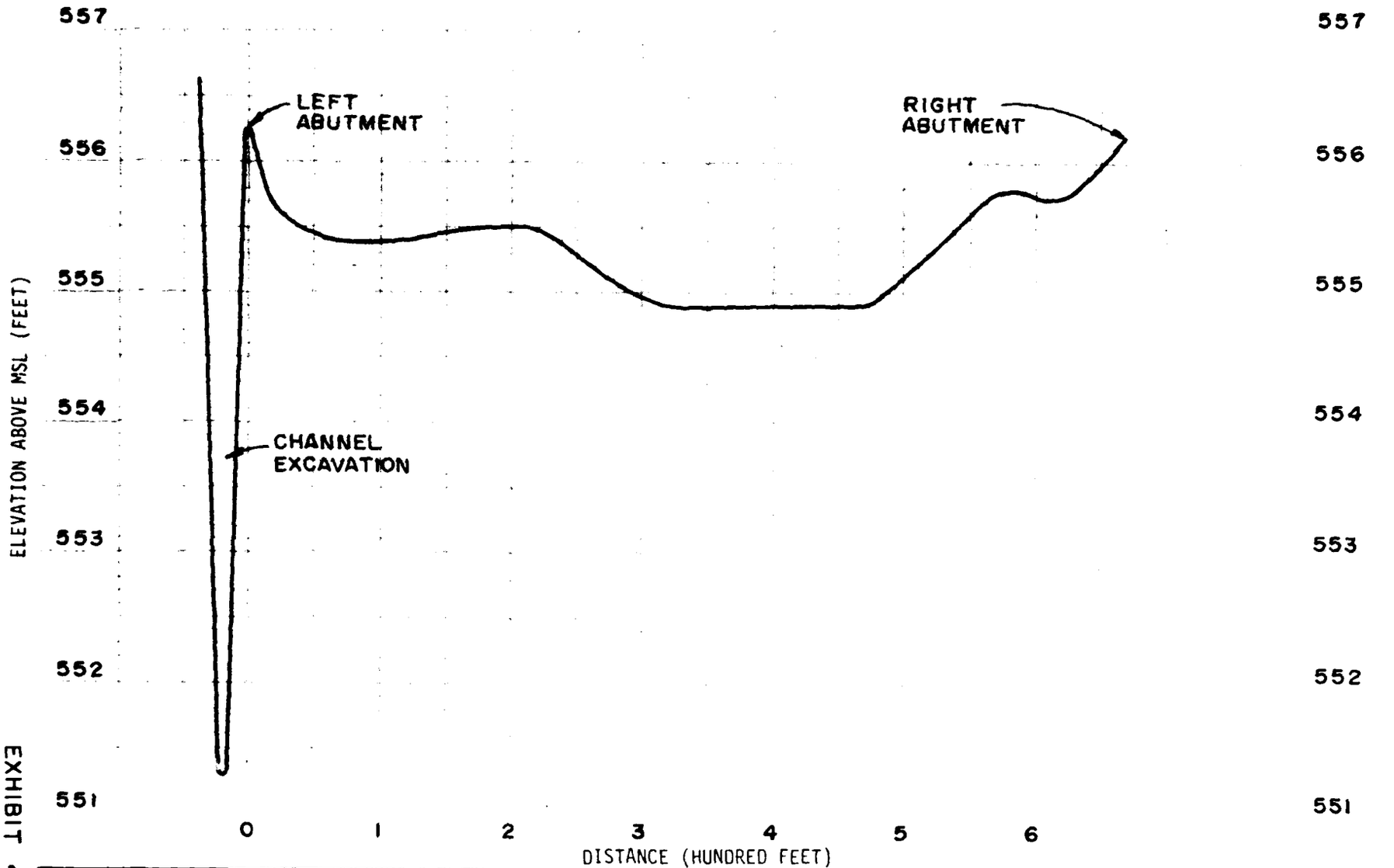
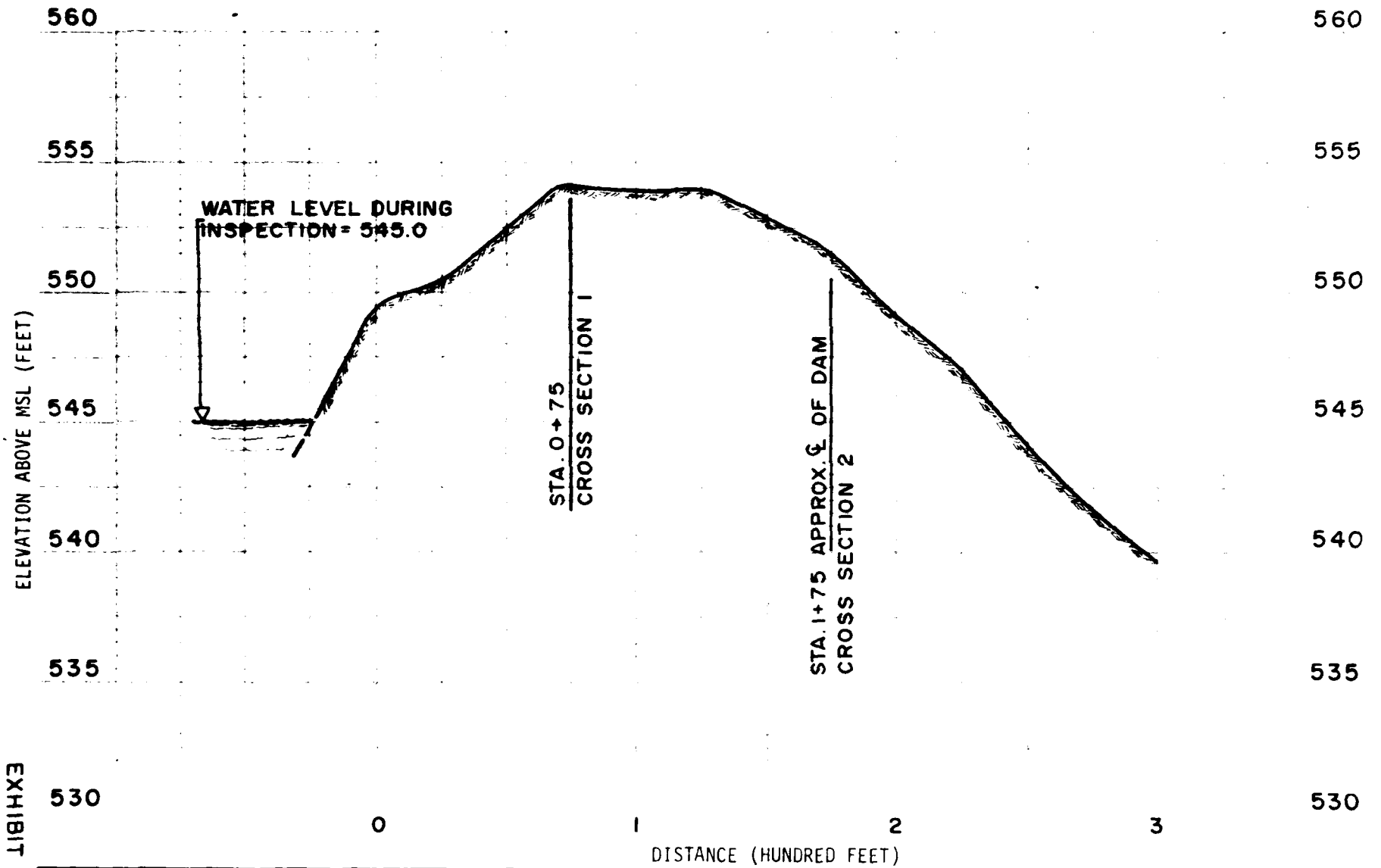


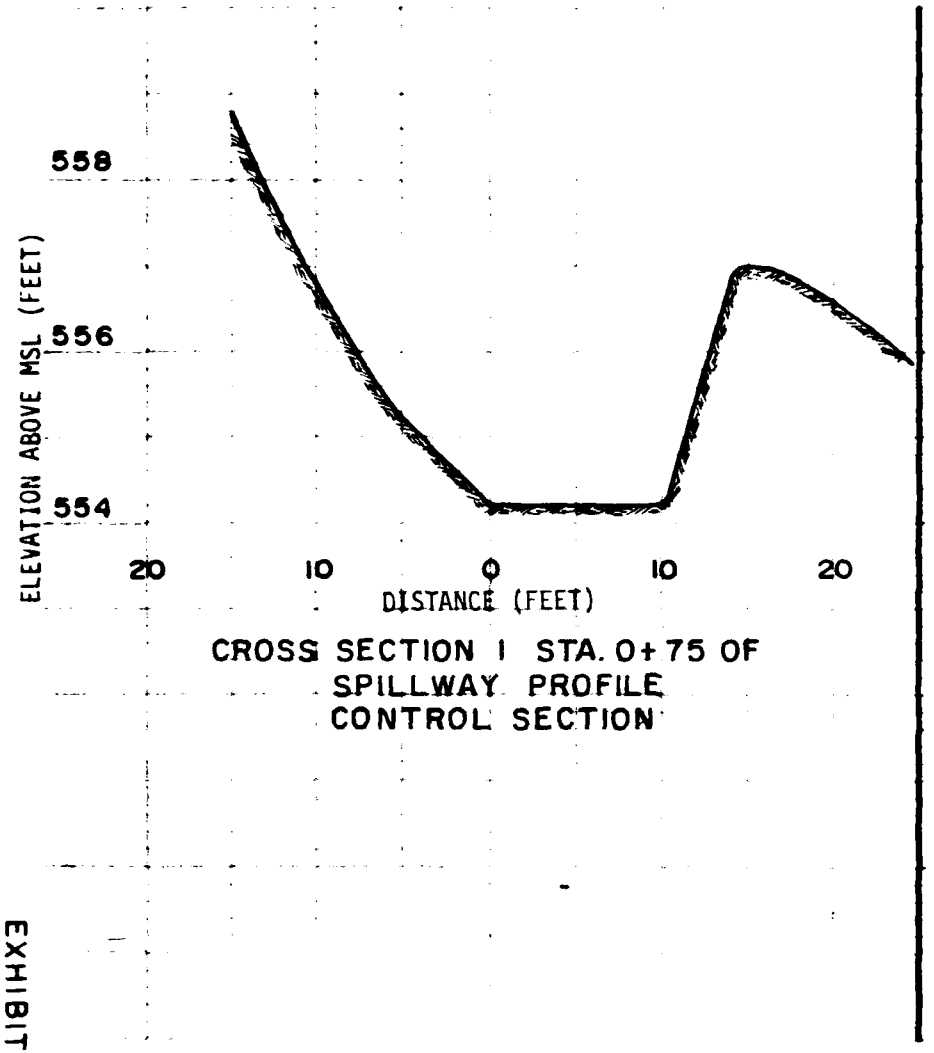
EXHIBIT 4

CRAWFORD MURPHY & TILLY, Inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	PROFILE OF DAM CREST LAKE BOUTIN DAM MO40008

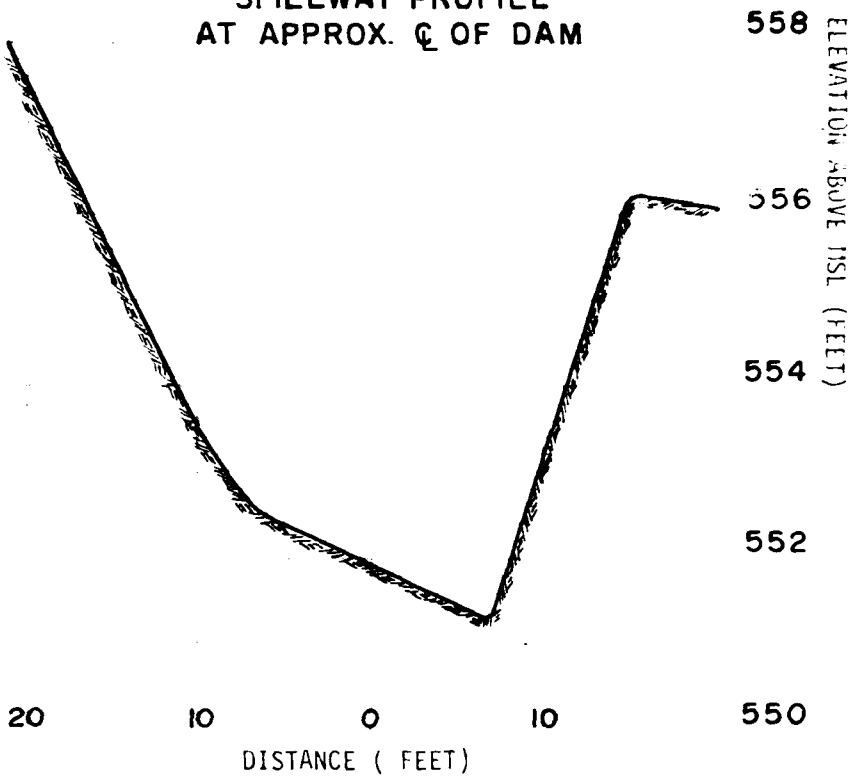
EXHIBIT 5



CLAYPOOL BOEPPLE & TILLEY, Inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	SPILLWAY FLOWLINE PROFILE LAKE BOUTIN DAM MO40008



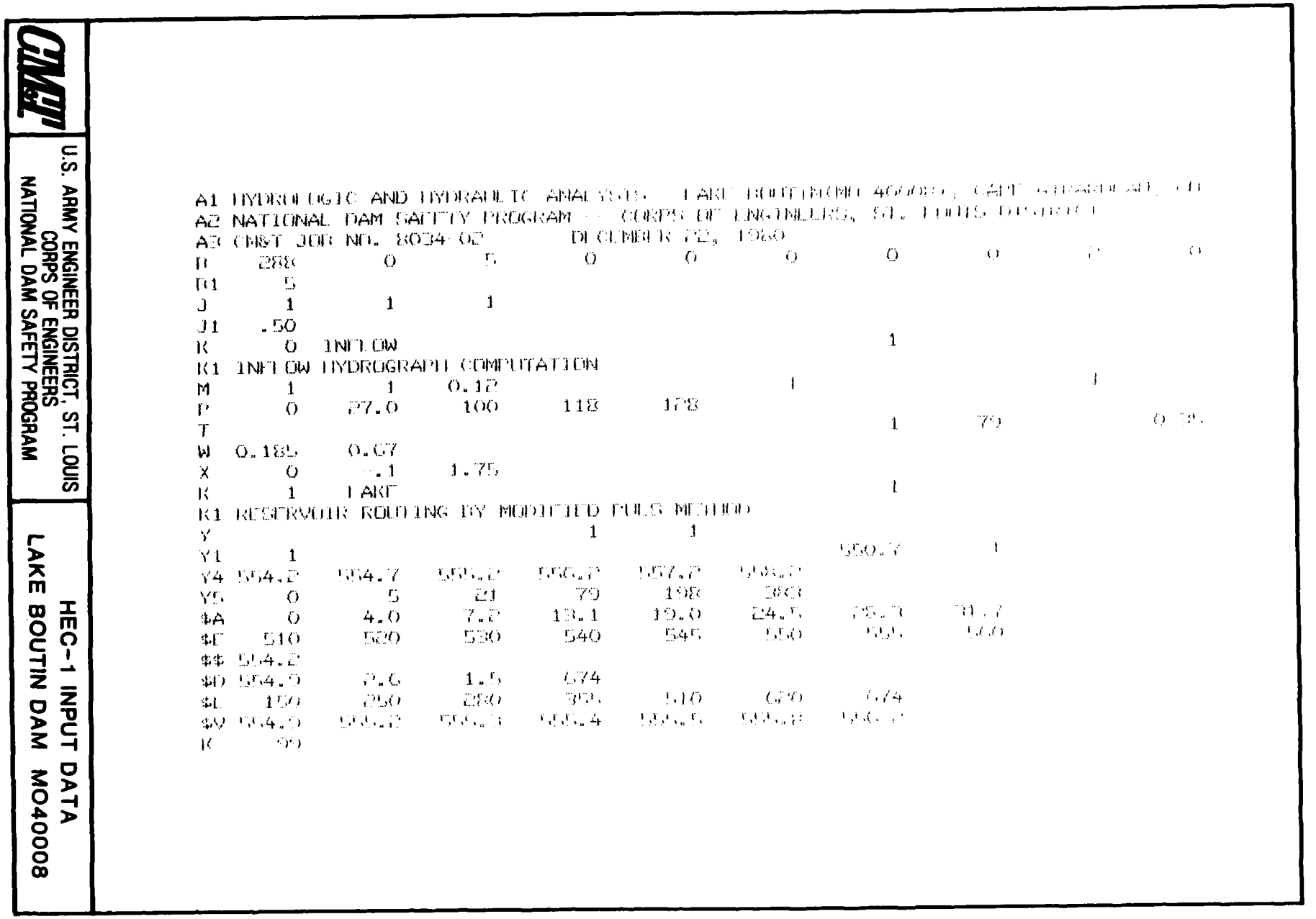
CROSS SECTION 1 STA. 0+75 OF
SPILLWAY PROFILE
CONTROL SECTION



CROSS SECTION 2 STA. 1+75 OF
SPILLWAY PROFILE
AT APPROX. ℄ OF DAM

EXHIBIT 6

CRAWFORD, MURPHY & TILLY, Inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	SPILLWAY CROSS SECTIONS LAKE BOUTIN DAM MO40008



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

HEC-1 INPUT DATA
LAKE BOUTIN DAM MO40008

```
A1 HYDROLOGIC AND HYDRAULIC ANALYSIS -- LAKE BOUTIN(MO 40008), CAPE GIRARDEAU, MI
A2 NATIONAL DAM SAFETY PROGRAM -- CORPS OF ENGINEERS, ST. LOUIS DISTRICT
A3 CMST JOB NO. 8034-02          DECEMBER 22, 1980
B     288         0         5         0         0         0         0         0         0         0
B1      5
J       1         1         1
J1    .50
K       0  INFLOW                                                    1
K1 INFLOW HYDROGRAPH COMPUTATION
M       1         1     0.17                              1                                   1
P       0      27.0       100       118       178
T                                                                    1        79                  0.75
W   0.185      0.67
X       0        .1      1.75
K       1  LAKE                                                      1
K1 RESERVOIR ROUTING BY MODIFIED PULS METHOD
Y                                           1         1
Y1      1                                                                 550.7         1
Y4  554.2     554.7     555.2     556.2     557.2     558.2
Y5      0         5        21        79       198       363
$A      0       4.0       7.2      13.1      19.0      24.5      75.3      81.2
$E    510       520       530       540       545       550       555       560
$$  554.2
$D  554.5       2.6       1.5       674
$L    150       250       280       325       510       670       674
$V  554.5     555.2     555.3     555.4     555.5     555.8     556.2
K      99
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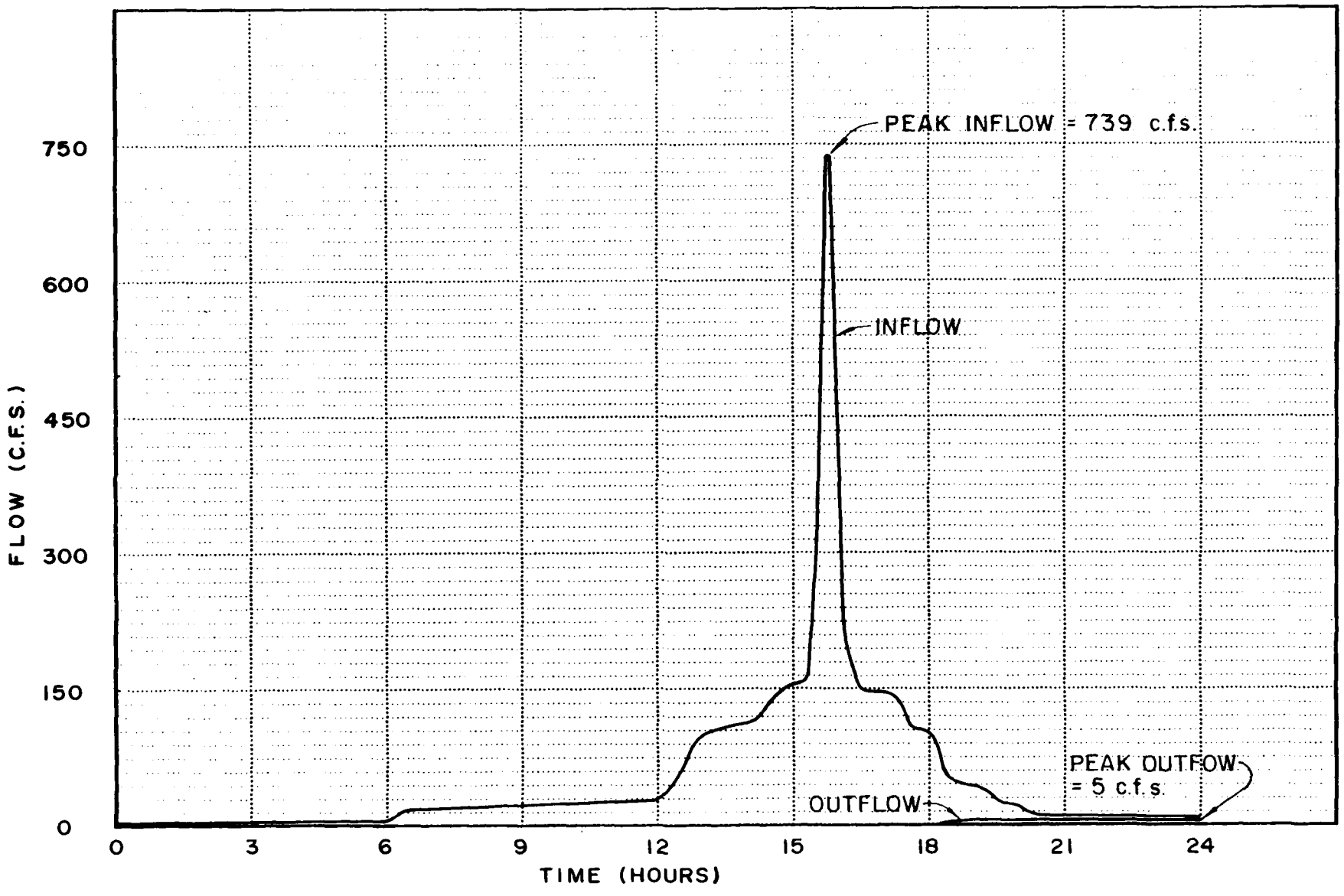
EXHIBIT 7

EXHIBIT 8



CRAWFORD, MURPHY & TILLY, inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	INFLOW AND OUTFLOW HYDROGRAPHS ---50% PMF LAKE BOUTIN DAM MO40008

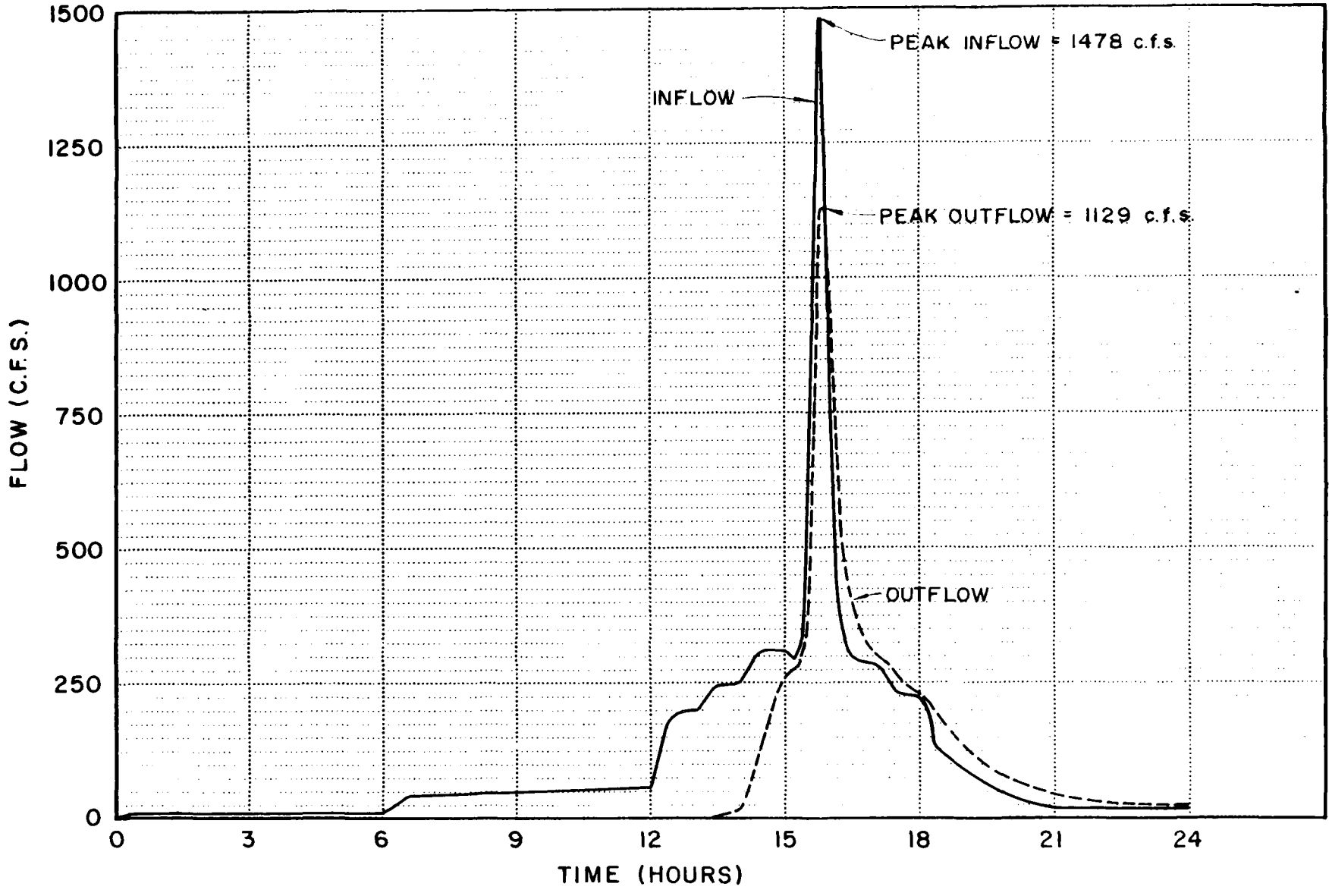


EXHIBIT 9

CRAWFORD MURPHY & TILLY, inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	INFLOW AND OUTFLOW HYDROGRAPHS--100% PMF LAKE BOUTIN DAM MO40008

CIMSL

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

HEC-1 SUMMARY TABLE 50% PMF
LAKE BOUTIN DAM MO40008

EXHIBIT 10

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

				RATIOS APPLIED TO FLOWS
OPERATION	STATION	AREA	PLAN	RATIO 1 .50
HYDROGRAPH AT	INFLOW	.12 (.31)	1	739. (20.93)(
ROUTED TO	LAKE	.12 (.31)	1	5. (.14)(

1

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	550.70	554.20	554.90
STORAGE	374.	466.	480.
OUTFLOW	0.	0.	11.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	554.70	0.00	480.	5.	0.00	24.00	0.00

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

HEC-1 SUMMARY TABLE 100% PMF

LAKE BOUTIN DAM MO40008

EXHIBIT 11

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1 1.00
HYDROGRAPH AT	INFLOW	.12 (.31)	1	1478. (41.86)
ROUTED TO	LAKE	.12 (.31)	1	1129. (31.97)

1 SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

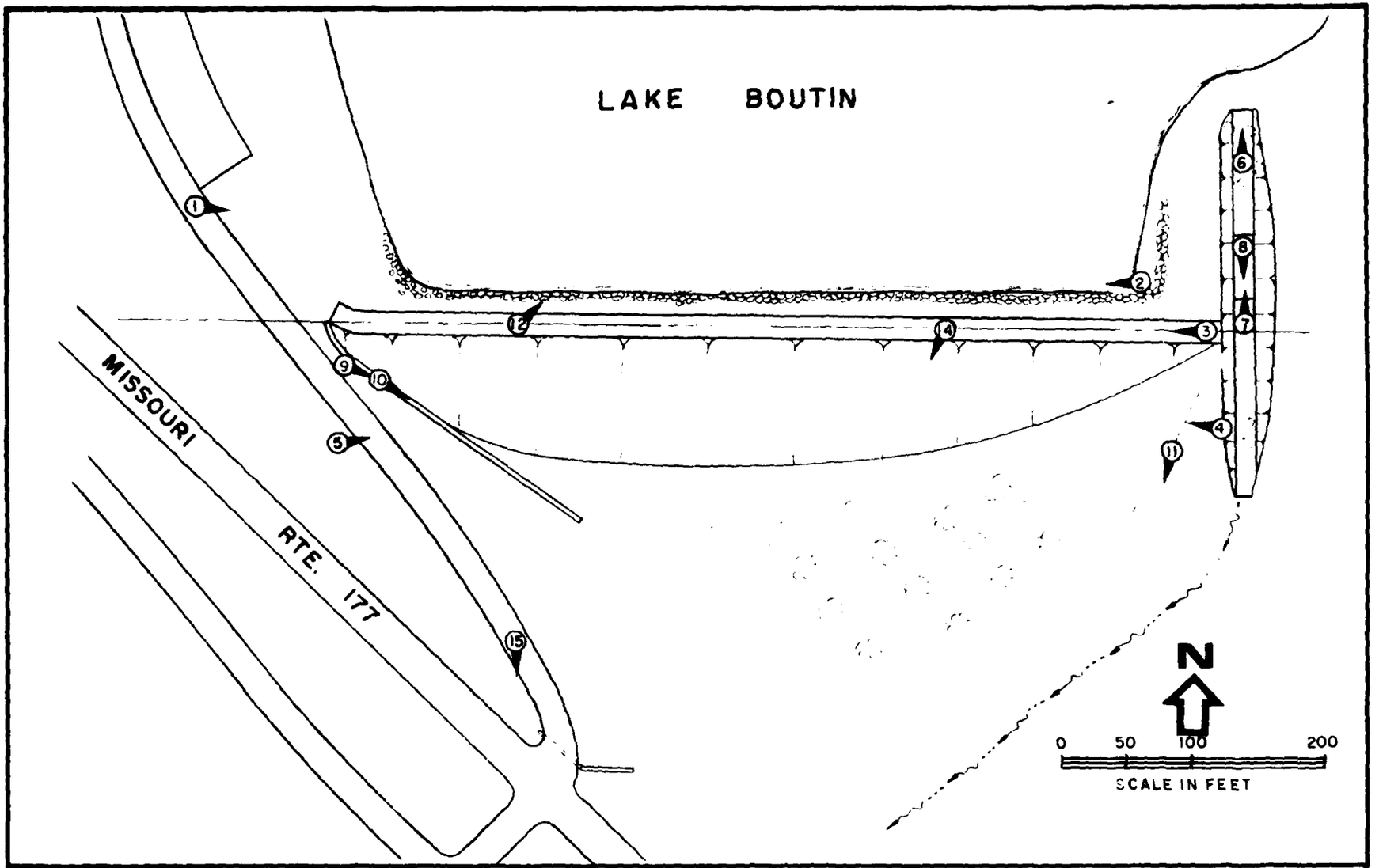
	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	552.80	554.00	554.00
STORAGE	428.	480.	480.
OUTFLOW	0.	0.	11.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	555.91	1.01	515.	1129.	10.08	15.83	0.00

PHASE I INSPECTION REPORT

APPENDIX C

PHOTOGRAPHS



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NATIONAL DAM SAFETY PROGRAM

PHOTOGRAPH INDEX
LAKE BOUTIN DAM MO40008

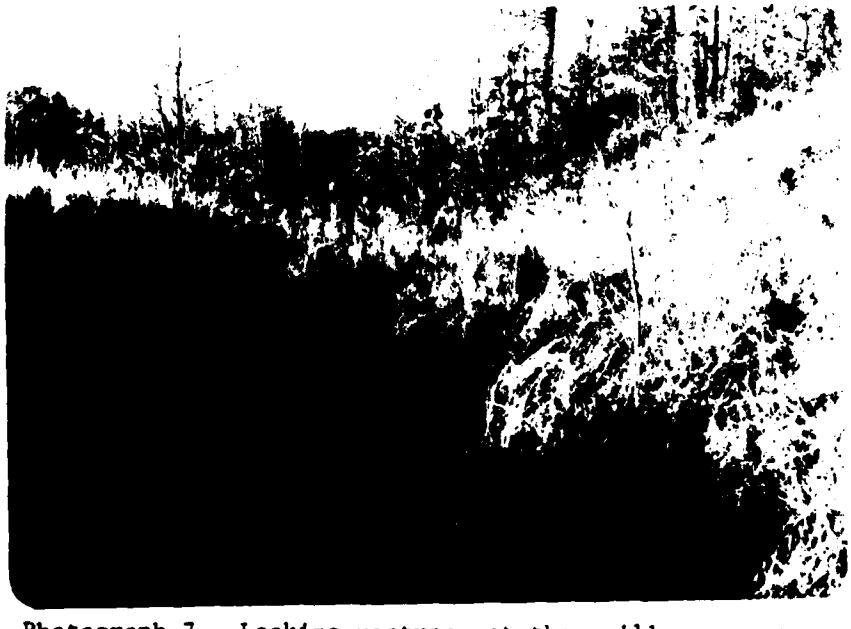
Photograph 2. Upstream slope of dam viewed from the left abutment.

Photograph 3. Crest of dam viewed from left abutment.

Photograph 4. Downstream slope of dam viewed from near the left abutment.

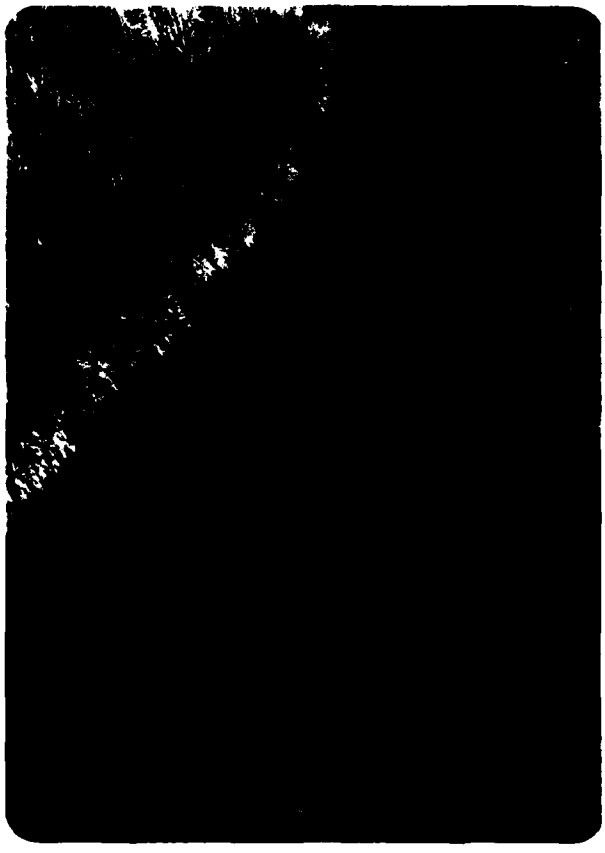
Photograph 5. Downstream slope of dam viewed from the right abutment.

Photograph 6. Looking upstream at the spillway approach channel from the spillway crest.

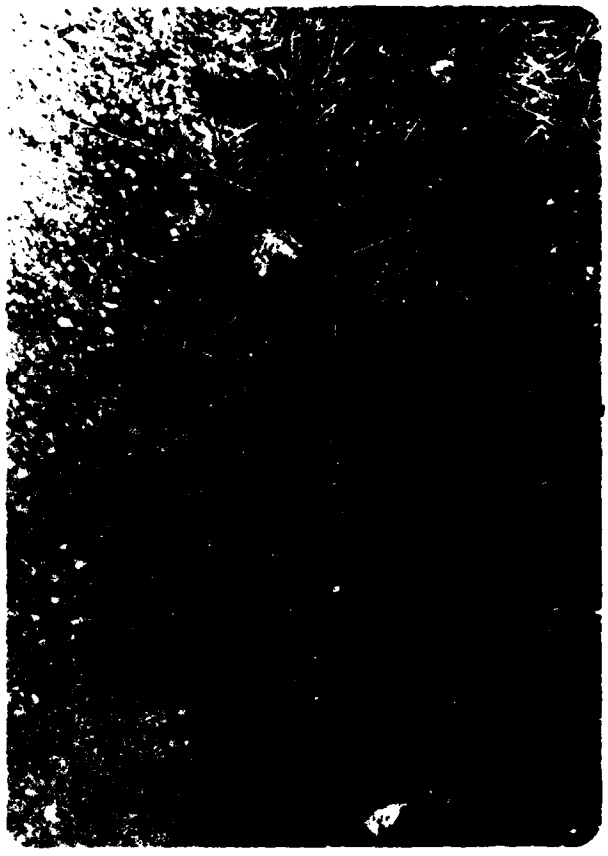


Photograph 7. Looking upstream at the spillway crest.

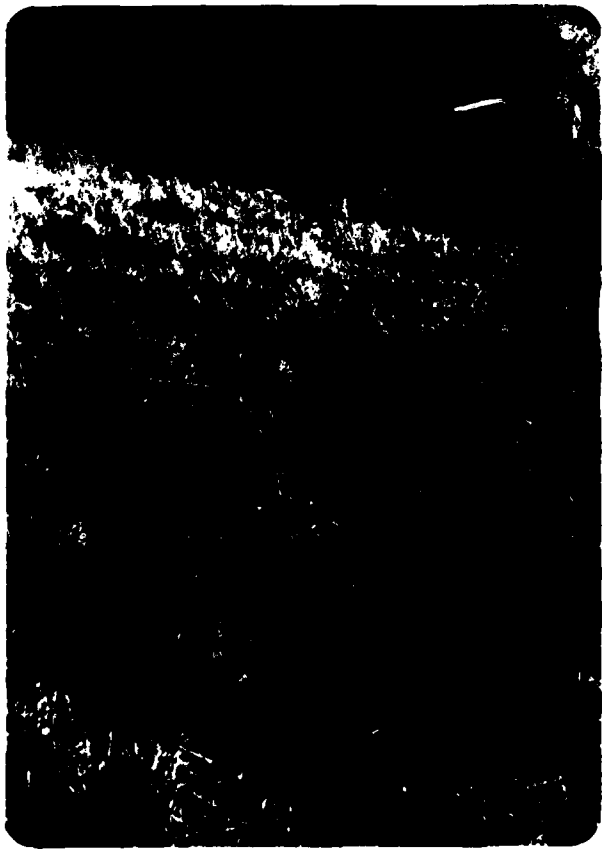
Photograph 8. Looking downstream from spillway crest.



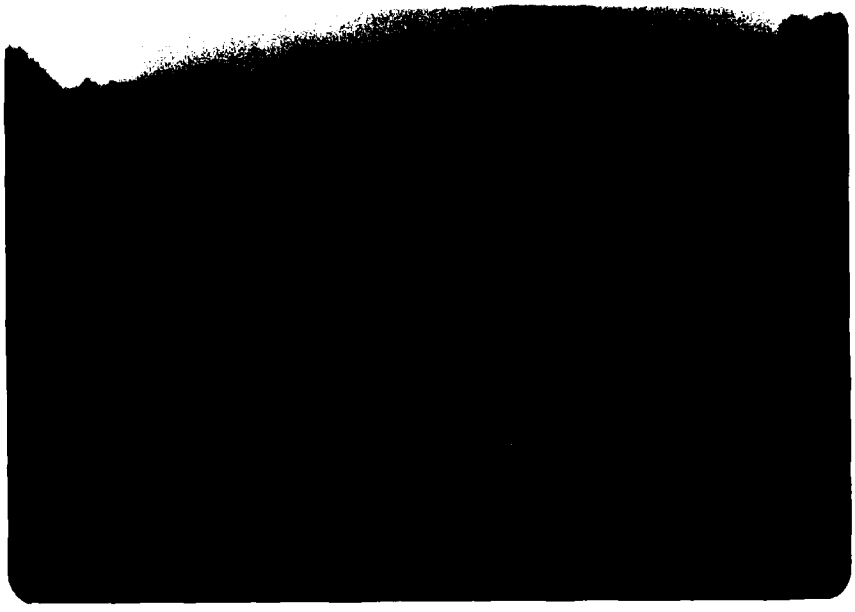
Photograph 9. Concrete gutter that runs along the downstream slope at the right abutment.



Photograph 10. Close-up view of cracking, hole, and undermining occurring in concrete gutter shown in Photograph 9.

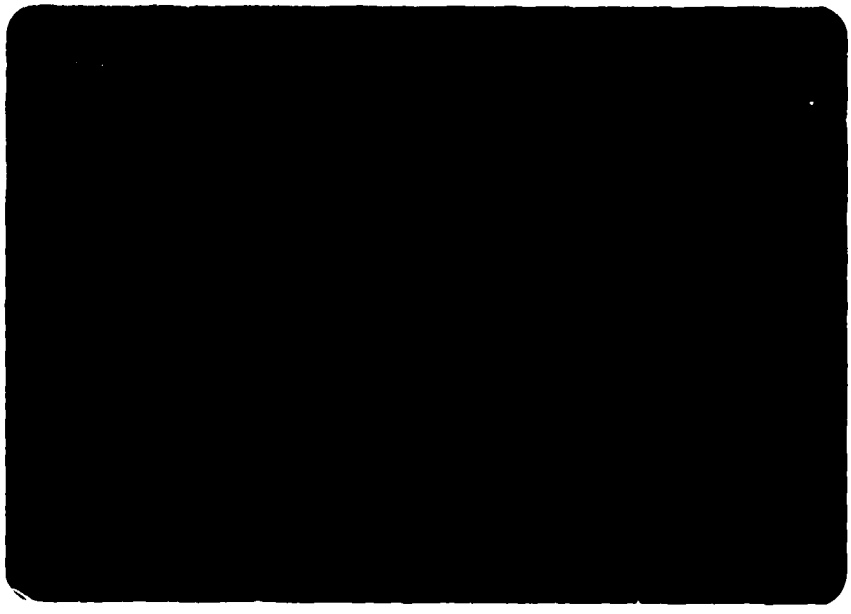


Photograph 11. View showing 3 feet deep erosion gully at left abutment on downstream slope.



Photograph 12. Looking from the dam across Lake Boutin at the recreational area and surrounding wooded areas.

Photograph 13. Typical heavily forested area of drainage area near upstream boundary.



Photograph 14. View of Missouri Route 177 just downstream of dam looking from near the left abutment.

Photograph 15. Looking downstream at mobile home located in the flood plain just downstream of Missouri Route 177.

Photograph 16. Dwelling located in hazard area about 1.3 miles downstream from the dam.

PHASE I INSPECTION REPORT

APPENDIX D

PREVIOUS INSPECTION REPORT

ENGINEERING GEOLOGIC REPORT OF REPORTED LEAKING LAKE - LAKE BOUTIN, TRAIL OF TEARS STATE PARK, CAPE GIRARDEAU, COUNTY, MISSOURI
FEBRUARY 15, 1978

LOCATION: NW¼, Sec. 15, T. 32 N., R. 14 E., Ware 7½' Quadrangle.

Source of information that lake is leaking: Jack L. Painter, DEQ, Poplar Bluff, incidentally mentioned in a letter to Bob Knight, about a water well problem at Trail of Tears State Park, that the park Superintendent thought the lake in the park was losing water. Jack thought that someone at the Survey would be interested in looking at the lake.

LAKE SITE INVESTIGATION:

On February 15, 1978, Lake Boutin was visited. Frozen ground, ice, water, and a partial snow cover prevented a thorough investigation of the lake. However, an examination of the visable portions of the dam did show some deficiencies in the dam that indicate a possible serious safety hazard.

The downstream slope of the dam had at least one open hole approximately one (1) foot in diameter and three (3) feet deep (photograph on file at DG&LS). This hole is located approximately 40% of the crest length from the left abutment (facing downstream). Another smaller hole associated with a crack was located nearby.

Several large areas of the downstream slope of the dam had a very irregular surface. The irregular surface could have been caused by erosion or by numerous small slumps. Because of the frozen ground and cover of weeds, the precise reason for the irregularities could not be determined. It is my present opinion that both slumping and erosion have occurred.

The downstream slope of the dam is quite steep near the crest and much flatter near the toe creating a dishshaped profile. This indicates that either the dam was constructed using a somewhat unusual cross-section for this size structure or the downstream slope has failed in the past and landscaping and/or repair was done.

A small amount of water was present in the drainage ditch downstream from the dam near where it crosses under Highway 177. This may be water that has leaked through the dam. Not much flow was noted but the frozen ground may have temporarily lowered the permeability of the soil in and around the dam. If this is water leaking through or under the dam, higher flow rates may occur after thawing.

A cursory examination of the spillway, which had a lining of snow, revealed a potential problem if the lake ever filled and the spillway received overflow. If the spillway ditch is not lined, which it did not appear to be, during periods of high flow, rapid erosion could occur. This could ultimately lead to serious erosion that will affect dam safety.

RECOMMENDATIONS:

Because of the potential for downstream flooding and damage to Highway 155 if the dam should fail, a close watch should be kept on the dam. Someone should walk across the downstream slope of the dam once a day to look for further deterioration of the dam. Particular attention should be paid to the area where the three foot

deep hole and crack were found. Additionally, when park personnel drive by the dam, observation of the downstream drainage ditch should be made to detect any increase in flow, particularly muddy flow.

At a later date, after the ground has completely thawed, snow cover melted, and "normal dry ground" conditions have returned, a further inspection of the dam should be made. As an aid to making this inspection plus the daily observations, the weeds on the dam should be mowed.

Further recommendations for more detailed observation, emergency drainage procedures, and repair suggestions will be made if the future more thorough investigation confirms the initial observations and indicates that these or other corrective procedures are warrented.

David Hoffman

David Hoffman, Geologist, P.E.
Applied Engineering & Urban Geology
Geology & Land Survey
February 24, 1978

END

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